Spread spectrum communication system

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Abstract

In the present spread spectrum communication equipment there are some problems that neeeding complicated distributing control for variable speed transmission and different speed transmission or increasing the hardware scaleare and the consum electricity. Low rate data D1-D4 and middle rate data D5 and D6 are time division multiplexed independently according to their rates by a time division multiplexer TDM(A) (110) so that their rates are converted into the rate of high rate data D7 and D8 which are not passed through the time division multiplexer TDM (A) (110). Subsequently, the entire data are converted into biorthogonal signals by biorthogonal signal generators BORTs (121, 122a-125a), and code division multiplexed by a code division multiplexer CDM(A) (130a). The code division multiplexed signal undergoes modulation by a spreading modulator and a carrier modulator, and transmitted.

CN1263675A Method of and apparatus for scheduling data transmissions in communication network

Bibliography

DWPI Title

Data transmission scheduling in communication network determining reverse link capacity available and assigning and sending transmission rate to user based on available capacity

English Title

Method of and apparatus for scheduling data transmissions in communication network

Assignee/Applicant

Standardized: **QUALCOMM INC**

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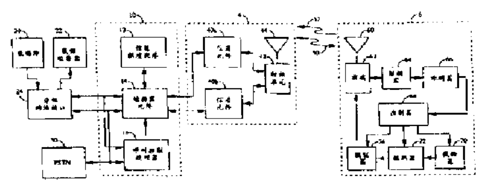
权利要求书 4 页 说明书 40 页 附图页数 11 页

[54]发明名称 在通信网中调度数据传输的方法和装置

[57]摘要

一种在通信网中对数据传输进行调度的方法和装置，通信网包含至少 一个小区(2a 到 2g)和至少一个预定的用户(6a 到 6c)，这种方法和装置提高 了反向链路的利用率，并降低了数据通信中的传输延迟。装置包含控制器 (92)，用来受所述通信网的状态信息，以及对从所述至少一个小区(2a 到 2g) 到所述至少一个预定用户(6a 到 6c)的数据传输进行调度。存储器(94)与所 述控制器相连，用来存储所述状态信息；调度程序(timer)(96)的连接用来 向所述控制器(92)提供时序信号。时序信号使得所述控制器能够进行数据传 输的调度。每一远端站在与小区的通信期间被分配了一个最大非预定传输速 率。最大预定传输速率可以由信道高度程序(scheduler)(12)分配，用以 在高速下数据的预定传输。最大预定传输速率是按照一组系统目标、一个系 统限制表以及有关通信网的状态的收集的信息来分配的。将数据分隔成数据 帧，并在以分配给预定用户的最大预定传输速率下或低于该速率在反向链路 上传送。



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权　利　要　求　书

1. 一种在通信网中的反向链路上进行数据传输调度的方法，所述通信网包含至少一个小区以及至少一个预定用户，其特征在于，所述方法包含下述步骤：

为所述至少一个小区中的每一个小区确定一个可用的反向链路容量；

向所述至少一个预定用户中的每一个用户分配一个分配的传输速率；以及

向所述至少一个预定用户发送所述分配的传输速率；

其中，所述分配的传输速率是基于每一所述至少一个小区的所述可用的反向链路容量的。

2. 如权利要求 1 所述的方法，其特征在于，所述确定步骤、所述分配步骤以及所述发送步骤，每 K 帧重复一次，其中，K 是大于或等于 1 的整数。

3. 如权利要求 1 所述的方法，其特征在于，所述分配步骤还进一步包含下述步骤：

为所述至少一个预定用户中的每一个确定一个工作成员组，所述工作成员组包含至少一个与所述预定用户进行通信的小区；

其中，所述分配的传输速率还基于所述工作成员组中每一所述至少一个小区的所述可用反向链路容量。

4. 如权利要求 3 所述的方法，其特征在于，所述分配步骤还包含下述步骤：

从至少一个预定用户中的每一个用户接收一个队列大小，所述队列大小决定要由所述至少一个预定用户中的每一个传送的数据量；

其中，所述分配的传输速率还基于来自所述至少一个预定用户中的每一个的所述队列大小。

5. 如权利要求 4 所述的方法，其特征在于，所述分配步骤还包含下述步骤：

产生预定用户的优先顺序表，所述优先顺序表包含所述至少一个预定用户中的每一个，其中，所述至少一个预定用户中的每一个被分配有一个优先顺序；

其中，所述分配的传输速率还基于所述至少一个预定用户中的每一个的所述优先顺序。

6. 如权利要求 5 所述的方法，其特征在于，所述分配步骤还包含下述步骤：

从所述预定用户的优先顺序表中选择一个选择的用户，所述选择的用户在所述优先顺序表中的所述至少一个预定用户中具有最高的优先顺序；

由所述选择的用户的所述工作成员组中的所述至少一个小区中的每一个计算所述选择的用户的最大可支持传输速率；

从所述最大可支持传输速率中选择一个最小的传输速率，所述最小的传输速率被定义为是最大的传输速率；并且

其中，所述分配的传输速率是在所述最大传输速率处，或低于该最大传输速率。

7. 如权利要求 6 所述的方法，其特征在于，所述分配步骤还包含下述步骤：

建议一个较佳传输速率，所述较佳传输速率是基于所述选择的用户的所述队列大小；

其中，所述分配的传输速率是在所述较佳传输速率处，或低于该较佳传输速率。

8. 如权利要求 7 所述的方法，其特征在于，所述分配步骤还包含下述步骤：

更新所述选择的用户的所述工作成员组中所述至少一个小区中的每一个的所述可用反向链路容量，以反映分配给所述选择的用户的容量；以及

从所述优先顺序表中去掉所述选择的用户。

9. 如权利要求 2 所述的方法，其特征在于，它还包含下述步骤：

使所述至少一个预定用户的零或更多的所述已分配的传输速率重新分配为一个临时的传输速率，其中，所述临时的传输速率取决于所述至少一个小区中的每一个的所述可用反向链路容量。

10. 如权利要求 9 所述的方法，其特征在于，所述重新分配的步骤还包含下述步骤：

产生一个通信网中的所述至少一个小区中的受影响小区的临时小区表，所述受影响(affected)的小区具有将数据发送到至少一个预定用户的不

合适的发射功率。

11. 如权利要求 10 所述的方法，其特征在于，所述重新分配的步骤还包含下述步骤：

产生一个受影响的预定用户的临时优先顺序表，所述受影响的预定用户包含通信网中所述至少一个预定用户。

12. 如权利要求 11 所述的方法，其特征在于，所述重新分配的步骤还包含下述步骤：

从受影响的预定用户的所述临时优先顺序表中选择出一个受影响的预定用户，所述选择的受影响的预定用户在所述临时优先顺序表中的所述至少一个预定用户中具有最高的优先顺序；

由所述选择的受影响的预定用户的所述工作成员组中的一个或多个所述至少一个小区计算所述选择的受影响的预定用户的最大临时可支持传输速率；以及

从所述最大临时可支持传输速率中选择出一个最小传输速率，所述最小传输速率定义为最大临时传输速率；

其中，所述临时传输速率是所述最大临时传输速率和所述分配的传输速率，或低于此二速率。

13. 如权利要求 12 所述的方法，其特征在于，所述重新分配的步骤还包含下述步骤：

更新所述选择的受影响的预定用户的所述工作成员组中的所述至少一个小区中的一个或多个的所述可用前向链路容量，以反映分配给所述选择的受影响的预定用户的容量；以及

从所述优先顺序表中去掉所述选择的受影响的预定用户。

14. 一种定时调度通信网中反向链路上的数据传输的装置，所述通信网包含至少一个小区和至少一个预定用户，其特征在于，所述装置包含：

用来收集所述通信网状态信息以及调度从所述至少一个小区到所述至少一个预定用户的数据传输的控制器装置；

与所述控制器装置相连用来存储所述状态信息的存储器装置；以及

与所述控制器装置相连用来向所述控制器装置提供信号的定时装置(timing means)，所述定时信号使得所述控制器装置能够进行对数据传输的调度。

15. 一种由对选择的数据进行调度来控制通信的系统，通过对选择的数据的调度而使数据在一个或多个基站与多个独立的远端站之间传送，每一个远端站具有独立的通信要求，数据的转发是根据远端站独立的要求以及一个或多个基站中的通信资源而调度的。

说 明 书

在通信网中调度数据传输的方法和装置

发明背景

I. 发明领域

本发明涉及一种在通信网中调度数据传输的方法和装置。本发明尤其涉及在通信网的反向链路上调度数据传输的方法和装置。

II. 相关领域的描述

目前，人们需要一种现代的通信系统来适应各种应用场合。一种这样的通信系统是码分多址(CDMA)系统，它符合“双模式宽带扩展谱蜂窝系统的TIA/EIA/IS-95A 移动站-基站兼容标准(TIA/EIA/IS-95A Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System)”，下文中称为 IS-95A 标准。CDMA 系统使得用户能够地面链路上相互进行话音和数据通信。在多址通信系统中采用 CDMA 技术的情况见标题为“SPREAD SPECTRUM MULTIPLE ACCESS COMMUNICATION SYSTEM USING SATELLITE OR TERRESTRIAL REPEATERS”的美国专利 4,901,307，以及标题为“SYSTEM AND METHOD FOR GENERATING WAVEFORMS IN A CDMA CELLULAR TELEPHONE SYSTEM”的美国专利 5,103,459。二专利已转让给本发明的受让人，在此引述供参考。

IS-95A 标准的设计使得话音通信为最佳，并选择许多重要的系统设计参数来实现这一目标。例如，由于说话者之间的时延是不能容忍的，所以必须设法使处理时延最小。向每一用户分配一个传输速率，这一速率使得能够承载(carry)该呼叫期间内的话音数据。呼叫终断以后，已分配的传输速率可以重新分配给另一个用户。

在 CDMA 系统中，用户通过一些远端站相互进行通信，而这些远端站通过一个或多个基站相互进行通信。本说明书中，基站指的是远端站与之进行通信的硬件。根据术语所在的上下文，小区可以是指硬件或地理覆盖区。

在 CDMA 系统中，用户间进行的通信是通过基站所服务的一个或多个小区来进行的。通过在与小区链接的反向链路上传送话音数据，一个远端站上

的第一用户与第二远端站或标准电话上的第二用户进行通信。小区接收话音数据，并且可以选择数据通向另一个小区或公共交换电话网(PSTN)的路由。如果第二个用户是在一个远端站上，则数据是在同一小区的前向链路或第二个小区上传送到第二个远端站的。否则，数据通过 PSTN 选择通向标准电话系统上的第二个用户的路由。在 IS-95A 系统中，前向链路和反向链路所分配得到的频率不同，并且是相互独立的。

在进行通信时，远端站至少与一个小区进行通信。CDMA 远端站能够在软切换时同时与多个小区进行通信。软切换是一个在切断与前一个小区的链路之前，与新的小区建立起一条链路的过程。软切换使丢失呼叫的可能性为最小。在软切换期间通过一个以上个小区与远端站进行通信的方法和系统见标题为“MOBILE ASSISTED SOFT HANDOFF IN A CDMA CELLULAR TELEPHONE SYSTE”美国专利 5,267,261，该专利已转让给本发明受让人并在此引述供参考。由于在进行新的资源分配时，必须考虑软切换中所包含的每一小区的状态和能力，所以软切换会对 CDMA 系统的各个方面产生影响。

按照 IS-95A 标准，每一远端站在与一个小区进行通信时，在反向链路上分配有一个 28,8Kbps 的传输速率。采用速率 1/3 卷积编码器，每一远端站的数据速率接近 9.6Kbps。尽管 IS-95A 标准没有规定，更高的数据速率可以用其他的编码速率来支持。例如，14.4Kbps 的数据速率是用速率 1/2 卷积编码器来实现的。

CDMA 系统是一个扩展谱通信系统。扩展谱通信的优点在本领域中是人们熟知的，并且这些优点可以通过参考上述参考文献来得知。CDMA 系统必须在蜂窝带中预先存在的非相邻频率分配中工作。设计时，向符合 IS-95A 标准的 CDMA 系统分配一个 1.2288MHz 的带宽，从而使蜂窝带得到完全的利用。反向链路指的是从远端站到小区的传输。反向链路上，28.8Ksps 的传输速率是在整个 1.2288MHz 系统带宽上扩展的。

反向链路上，每一传送远端站的作用是对网络中的其他远端站进行干扰。所以，反向链路的容量受到远端站所经受的来自其他远端站的总干扰的限制。通过传送较少的位，IS-95A 系统增加了反向链路的容量，从而在用户不说话时使用较低的功率，并使干扰降低。

为了使干扰为最小，而同时使反向链路容量为最大，由两个功率控制回路来控制每一远端站的发射功率。第一个功率控制回路来调节远端站的发

射功率，使得在小区处接收的信号的每一位的能量与噪声加干扰的比值 $E_b/(N_o+I_o)$ 保持在恒定的水平上。这一水平称为 $E_b/(N_o+I_o)$ 设置点。第二个功率控制回路调节这一设置点，使得保持由帧差错率(FER)测得的要求的性能水平。反向链路的功率控制机构详见标题为“METHOD AND APPARATUS FOR CONTROLLING TRANSMISSION POWER IN A CDMA CELLULAR MOBILE TELEPHONE SYSTM”的美国专利 5,056,109，此专利已转让给本发明的受让人，在此引述供参考。

用户根据说话时语言活动的水平，发射不同的位速率。用户说话频繁时，可变速率语音编码器提供全速率的话音数据，而在无声(例如停顿)时提供低速率的话音数据。可变速率编码器详见标题为“VARIABLE RATE VOCODER”的美国专利 5,414,796，该专利已转让给本发明的受让人，在此引述供参考。

对于 CDMA 系统，由可由小区支持的用户数测得的远端站和小区之间的话音通信的反向链路容量可以由每一远端站上用户的传输速率来确定。这是因为其他可由反向链路容量确定的参数是由系统设计来决定的，或者是已知的。例如，每一远端站的最大发射功率受 FCC 规则限制，也受系统设计的限制。保持要求的性能水平所需的 $E_b/(N_o+I_o)$ 取决于不能控制的信道条件。最后，由设计来选择 1.2288MHz 的 CDMA 系统带宽。

给定时刻话音活动量是不确定的。同时，用户间的话音活动水平通常也是不相关的。所以，小区处从所有发送远端站接收的总功率随时间而变，并且可以近似用高斯(Gaussian)分布来表示。在繁忙的通话的时候，远端站发送更高的功率，对其他的远端站产生更多的干扰。更多的干扰使得其他远端站的接收 $E_b/(N_o+I_o)$ 降低，并且如果功率控制不能进行动态跟踪的话，则使帧出现差错的几率增大。所以，使能够访问通信系统的用户数受到限制，从而只有少部分的发射帧因为过量干扰而丢失。

限制反向链路容量以保持所要求的帧差错率(FER)使得平均起来，具有使小区在小于全部容量的情况下进行工作，从而没有全部利用反向链路容量。在最差的情况下，最多有一半的反向链路容量被浪费，从而可以有多达 3dB 的自由空间。这一自由空间是小区可以接收的增大功率与小区实际接收的平均功率之差。该自由空间仅在远端站处用户的话务量大时才利用。

CDMA 系统中的数据通信具有与话音通信不同的特征。例如，数据通信的特征通常是被高突发数据业务所中断的长时间不工作，或低工作量。对数

据通信的一个重要的系统要求是需要有传输延迟来转发突发数据(burst of data)。传输延迟对数据通信的影响与对话音通信的延迟是不同的，但对于测量数据通信系统的质量，这是一个重要的优点。

在固定大小的编码信道帧中传送数据业务的方法(其中，数据源在可变速率下提供数据)详见标题为“METHOD AND APPARATUS FOR THE FORMATTING OF DATA FOR TRANSMISSION”的美国专利 5,504,773，该专利已转让给本发明的受让人，在此引述供参考。将数据分隔成数据帧，每一数据帧接着被分隔成数据部分。接着将数据部分编码成编码信道帧，它可以是 20 毫秒宽。在 28.8Ksps 的码元速率下，每一 20 毫秒宽的编码信道含有 576 个码元。速率 1/2 或速率 1/3 卷积编码器根据应用场合，用来对数据进行编码。采用速率 1/3 编码器，数据速率近似为 9.6Kbps。在 9.6Kbps 的数据速率下，每一编码信道帧有 172 个数据位、12 个循环冗余检验(CRC)位和 8 个编码尾位。

在反向链路上进行高速数据传输可以通过在多个编码信道上同时传送数据业务来实现。采用多个编码信道来进行数据传输的情况见申请日为 1996 年 5 月 31、标题为“METHOD AND APPARATUS FOR PROVIDING RATE SCHEDULED DATA IN A SPREAD SPECTRUM COMMUNICATION SYSTEM”的美国专利申请 08/656,649，以及申请日为 1996 年 5 月 28 日、标题为“HIGH DATA RATE CDMA WIRELESS COMMUNICATION SYSTEM”的美国专利申请 08/654,443。二专利已转让给本发明的受让人，在此引述供参考。

对反向链路的要求因话务量(voice activity)水平的变化而随时间而变。通过在话务量较低时传送数据业务，可以改进反向链路没有充分利用的情况。为了避免话音通信质量变差，应当对数据传输进行动态调整，以适应小区已有的反向链路容量。

在处理较大的零星的突发数据业务时，应当使所设计的系统具有在高数据速率下进行发射的能力，以及根据现有的容量，在用户请求时向用户分配反向链路容量的能力。在 CDMA 系统中，设计时还应当考虑系统已有的其他方面。首先，因为话音通信不容许有无限制的延迟，所以在传输任何一种数据业务时，应当给予话音数据的传输以优先权。其次，由于任一给预定刻的话务量是无法预计的，所以，应当连续监视反向链路，并且动态调整数据传输，使得不会超过反向链路容量。第三，由于可以在多个小区之间对远端站进行软切换，所以应当根据软切换中参加的每一个基站的反向链路容量，

来分配数据传输速率。本发明中对这些问题作了考虑。

发明概述

本发明的目的是，通过提供在高速传输速率下传送数据业务的装置，可以改进反向链路的利用，并降低 CDMA 系统中数据通信的传输延迟。在与小区进行通信期间，每一远端站可以在反向链路上在直至最大非预定(unscheduled)传输速率下进行非预定传输。按照 IS-95A，最大非预定传输速率是 28.8Ksps。非预定传输可以用来发送数量较少的数据和进行消息控制，而不会因预定而引起附加的延迟。另外，可以向每一远端站分配一个最大的预定(scheduled)传输速率，该最大预定传输速率高于最大的非预定传输速率。本发明中，信道调度程序(scheduler)决定高速数据传输的最大预定传输速率。按照反向链路容量的情况，在每一预定时间内分配最大预定传输速率。

本发明的目的还在于改善 CDMA 系统中反向链路容量的利用。当远端站具有大量要发送到小区的数据时，信道调度程序收集有关有多少数据要传送、网络中每一小区已有的反向链路容量的信息以及下面将要讨论的其他参数。根据收集的信息，并按照系统目标表和系统限制表，信道调度程序分配最大预定传输速率。将最大预定传输速率发送到远端站。远端站将数据分隔成数据帧，并在最大预定传输速率下或在低于最大预定传输速率下，在反向链路上发送数据。

本发明的目的还在于使反向链路上数据业务的传输延迟为最小。由信道调度程序，根据要传送的数据量，来分配预定的传输速率。数量较少的数据是在反向链路上在最大非预定传输速率或低于最大非预定传输速率的速率下直接传送的。对于数量更大的数据量，信道调度程序分配有关最大的预定传输速率。

本发明的目的还在于根据一组优先顺序，通过向用户分配已有的反向链路容量，来使反向链路的使用为最佳。根据一组因素，对系统中的用户进行优先顺序分配。这些因素包括用户对必要的性能水平所需的每位能量、支持用户的小区表、要传送的数据量、要传送的数据类型、要提供给用户的数据服务类型、用户已经经历的延迟量，以及其他的因素。已有的容量首先分配给优先顺序最高的用户，最后分配给优先顺序最低的用户。

本发明的一个方面是提供一种在通信网中在反向链路上对数据传输进行调度(scheduling)的方法，该通信网包含至少一个小区和至少一个经调度的用户，所述方法包含：确定所述至少一个小区中每一小区的反向链路容量；向所述至少一个经调度的用户中每一用户分配所赋予的传输速率；以及向所述至少一个经调度的用户发送所述分配的传输速率；其中，所述分配的传输速率是基于所述至少一个小区中的每一个小区的所述反向链路容量的。

本发明的另一个方面是提供一种在通信网中的反向链路上对数据传输进行调度的装置，通信网包含至少一个小区和至少一个经调度的用户，所述装置包含：收集用于所述通信网的状态信息并对从所述至少一个小区到所述至少一个经调度的用户的数据传输进行调度的控制器装置；与所述控制器装置相连用来存储所述状态信息的存储器装置；以及与所述控制器装置相连用来向所述控制器装置提供调度信号的预定装置，所述定时信号使得所述控制器装置能够进行对数据传输的调度。

本发明的其他方面是提供一种系统，在该系统中，通信是通过对选择的数据进行调度来控制的，所选择的数据用来在一个或多个基站与多个独立的远端站之间转发，每一远端站具有各自的通信要求，转发是根据远端站各自的要求以及一个或多个基站中所具有的通信资源来调度的。

附图简述

在结合附图对本发明的实施例进行了详细描述以后，读者将会清楚地理解本发明的特征、目的和优点，图中，相同的标号所表示的意义相同。

图 1 是一个蜂窝网的图，它包含多个小区、多个基站和多个远端站。

图 2 是 CDMA 通信系统中本发明的典型结构的方框图；

图 3 是信道控制器的方框图；

图 4 是远端站中典型编码器的方框图；

图 5 是远端站处典型调制器的方框图；

图 6 是远端站处另一种编码器和调制器的方框图；

图 7 是实施本发明的对反向链路速率进行调度的流程图；

图 8 是实施本发明的数据传输速率分配的流程图；

图 9 是实施本发明的数据传输速率再分配的流程图；

图 10 是传输速率分配和在分配的传输速率下进行的数据传输的时序

图；以及

图 11 是实施本发明的反向链路速率调度的典型应用的图。

较佳实施例的详细描述

参见附图，图 1 代表的是由多个小区 2a－2g 组成的典型的蜂窝通信网。每一小区 2 由相应的基站 4 服务。在本典型实施例中，尽管本发明可以应用于所有的无线通信格式，但这里的蜂窝网是 CDMA 通信网。在 CDMA 网中，分布着各个远端站 6。根据远端站是否处于软切换中，远端站 6 中的每一个与一个或多个基站 4 进行通信。例如，远端站 6a 和 6b 仅与基站 4c 进行通信，远端站 6d 和 6e 仅与基站 4d 进行通信，但靠近小区边界的远端站 6c 处于软切换状态，并同时与基站 4c 和 4d 进行通信。在 CDMA 系统中采用软切换的细节见上述美国专利 5,267,261 中的描述。

描绘实施本发明的 CDMA 网的基本结构的方框图如图 2 所示。基站控制器 10 与分组网络接口 24、PSTN30 以及 CDMA 网络中的所有的基站 4(为了简化，图 2 中仅画出了一个基站 4)接口连接。基站控制器 10 协调 CDMA 网络中的远端站 6 以及与分组网络接口 24 和 PSTN30 相连的其他用户之间的通信。尽管为简化起见，图 2 中仅画出了一个选择器元件 14，实际上，基站控制器 10 含有许多的选择器元件 14。分配一个选择器元件 14，用来控制一个或多个基站 4 和远端站 6 之间的通信。

在反向链路上，远端站 6 通过向基站 4 发出一条请求消息始发一个呼叫。基站 4 接收这条消息，并将这条消息传递到呼叫控制处理器 16。呼叫控制处理器 16 向选择器元件 14 发送一条命令，以指挥基站 4 来分配前向链路业务信道。基站 4 采用一条信道元件 40 来控制与远端站 6 的呼叫。在分配了业务信道以后，通知呼叫控制处理器 40。呼叫控制处理器 40 接着指令基站 4 在前向链路上将信道分配消息发送到远端站 6。

远端站 6 通过请求信道调度程序 12 的准许，在反向链路上发出高速数据传输。远端站 6 中的控制器 68 通过选择请求命令通向编码器 72 的路由，对请求进行处理。控制器 68 可以是在微控制器、微处理器、数字信号处理(DSP)芯片内的，也可以是 ASIC 编程的，以执行上述功能。在本典型的实施例中，编码器 72 按照上述美国专利 5,504,773 中描述的“空格和突发脉冲信令数据格式(Blank and Burst signalling data format)”，对请求命令进行编

码。编码器 72 产生并附上一组循环冗余检验(CRC)位、附上一组编码尾位，对数据和所附上的位进行卷积编码，并对经编码的数据码元进行重新排序。将经交错的位提供到调制器(MOD)74。调制器 74 用沃尔什(Walsh)编码映射将经交错的位映射到另一个信号空间。具体说来，将经交错的位组合成 6 个位一组。随后，将这 6 个位映射为相应的 64 个子码的沃尔什序列。接着，调制器 74 将沃尔什子码用长伪噪声(pseudo noise)(PN)码和短 PN 码来扩展。经调制的信号被提供到前端 62。前端 62 对信号进行滤波、放大，并将信号在空中通过天线 60 在反向链路 52 上发射出去。

远端站 6 按照长 PN 序列，对反向链路数据进行调制。在本典型实施例中，每一反向链路信道是按照公共长PN序列发生器的时移(temporal offset)来定义的。对于两个不同的偏移，产生的调制序列是不相关的。远端站 6 的偏移是按照远端站 6 特有的数字识别来决定的，在 IS-95 的典型实施例中，远端站 6 是电子序号(ESN)。所以，每个远端站 6 是在按照其特有的电子序号决定的一个不相关的反向链路信道上发射的。

在基站 4 处，反向链路信号由天线 44 接收，并提供到 RF 单元 42。RF 单元 42 对反向链路信号进行滤波、放大、下变频和量化，并将量化后的基带信号提供到信道元件 40。信道元件 40 对基带信号进行解调和译码，反方向的信号处理功能是在远端站 6 处完成的。信道元件 40 对具有短 PN 码和长 PN 码的数字化基带信号进行去扩展。随后，信道元件 40 对经去扩展的数据进行信号映射。具体说来，将经去扩展的数据分组成 64 个子码的块，并分配一个具有与经去扩展的数据块最接近的沃尔什序列的沃尔什码。沃尔什码包含经解调的数据。信道元件 40 随后对经解调的数据进行重新排序，对经解交错的数据进行卷积码译码，并执行 CRC 检验功能。将经译码的数据(例如请求命令)提供到选择器元件 14。选择器元件 14 请求命令选择通向信道调度程序 12 的路由。

信道调度程序 12 将基站控制器 10 内的所有选择器元件 14 连接起来。信道调度程序 12 分配一个可以由远端站 6 用于反向链路上的高速数据传输的最大预定传输速率。将用于远端站 6 的最大预定传输速率提供到选择器元件 14。选择器元件 14 选择调度信息通向信道元件 40 的路由，信道元件 40 对调度信息进行编码和调制。将经调制的信号提供到 RF 单元 42，该 RF 单元 42 对信号进行上变频和条件设置。信号是由天线 44 在前向链路 50 上发

射的。

在远端站 6 处，前向链路信号由天线 60 接收，并选择通向前端 62。前端 62 对接收的信号进行滤波、放大、下变频和量化，并将数字化的基带信号提供到解调器(DEMOD)64。数字化的基带信号由解调器 64 解调，并由译码器 66 进行译码，反方向的信号处理由信道元件 40 进行。选择含有最大预定传输速率的译码数据的通向控制器 68 的路由。控制器 68 接收调度信号，并构成硬件，在最大预定传输速率下以及在低于最大预定传输速率下开始数据传输。

高速数据传输基本上是以上述请求命令传输相同的方式出现的，例外的情况是，数据传输可以是发生在直至最大预定传输速率的速率下。在远端站 6 处，数据被分隔成数据帧。本说明书中，数据帧指的是，在一个帧的时间间隔内，从远端站 6 传送到基站 4 的数据量。数据帧接着被分隔成更小的称为数据部分的单元。数据帧从数据源 70 发送到编码器 72。编码器 72 将数据帧格式化，插入一组产生的 CRC 位和一组编码尾位，对数据进行卷积编码，并记录经编码的数据。对数据进行编码和交错的方法见上述美国专利 5,504,773。将经编码的数据帧提供到调制器 74，用沃尔什码进行信号映射。随后，调制器 74 用长伪噪声码和短 PN 码对映射数据进行扩展，并将扩展数据提供到前端 62。前端 62 对信号进行滤波、放大、上变频，在反向链路 52 上通过天线 44，在空中将信号发射出去。

基站 4 接收反向链路信号，并以上述方式对反向链路信号进行解调和译码。经译码的信号由信道元件 40 提供到选择器元件 14。选择器元件 14 将数据提供到分组网络接口 24，由它来选择数据通向数据接收器(data sink)22 的路由。上述硬件同时支持在 CDMA 网络上的数据通信和话音通信。

上述功能也可以由其他的方式来完成。信道调度程序 12 和选择器元件 14 的位置或者取决于所要求的是集中式的还是分布式调度处理方式。例如，信道调度程序 12 和选择器元件 14 可以包括在基站 4 内。这种分布式的处理方式使得每一个基站 4 能够执行其自身的调度，从而可以使处理延迟位最小。相反，可以将信道调度程序 12 设计成控制与网络中所有的基站 4 进行的通信。基站处理方式使得系统资源可以得到最佳的利用。这些例子描绘的是，信道调度程序 12 不是如本典型实施例中所描绘的那样，是组合在基站控制器 10 内的。也可以采用其他具有上述功能的结构，这同样也是在本发

明的范围内的。

可以将反向链路传输分为两种类型。第一种类型包含非预定任务，在本较佳实施例中，由于不容许有附加的处理延迟，所以是非预定的。这种类型包括话音通信和某些类型的数据通信(例如更高层次的确认消息)。第二种类型包括预定的任务，它允许有附加的处理和排队延迟。这种类型包括远端站 6 和基站 4 之间的大多数的数据通信。

如图 1 所示，多个远端站 6 分散在 CDMA 网中，并且可以同时与一个或多个基站 4 进行通信。所以，信道调度程序 12 协调在 CDMA 网上的预定和非预定任务的传输。反向链路上预定任务的传输是由信道调度程序 12 根据反向链路容量的情况来调度的，以便避免预定和非预定任务传输中的劣化。信道调度程序 12 的任务是这样来赋予的，即使其具有向 CDMA 网中远端站 6 上的每一预定用户分配数据传输速率的功能，从而使一组目标为最佳。这些目标包括：(1)通过传送与由系统容量限制中可以支持一样多的预定和非预定的任务，来提高反向链路容量的利用率，(2)改进通信质量，使传输延迟为最小，(3)根据一组优先顺序，向所有的预定用户平均分配反向链路容量，以及(4)使远端站 6 的发射功率为最小，以延长电池的寿命、减少干扰。通过平衡一个下面将要详述的因素表，可以使这些目标为最佳。

信道调度程序 12 的方框图如图 3 中所示。控制器 92 从 CDMA 网中所有的基站 4 收集合适的信息，并分配数据传输速率。控制器 92 可以在微控制器、微处理器、数字信号处理(DSP)芯片或一个编程的 ASCI 中实现，以执行这里所描述的功能。控制器 92 将基站控制器 10 中的所有选择器元件 14 连接起来。控制器 92 收集有关反向链路的要求和容量的信息。收集的信息存储在存储器元件 94 中，并根据需要，由控制器 92 检索。存储器元件 94 可以用有关存储元件，或任何数量的存储装置(如本领域中人们所知道的 RAM 存储装置、锁存器或其他类型的存储装置)中的一个来实现。控制器 92 还与预定元件 96 相连。预定元件 96 可以是一个由系统时钟运行的计数器、一个锁在外部信号上的机载振荡器(on board oscillator)，或者从一个外部源接收系统预定的存储元件。预定元件 96 向控制器 92 提供执行反向链路速率调度所必须的调度信号。调度信号还使得控制器 92 能够在合适的时间间隔内向选择器元件 14 发送最大预定传输速率。

I. 反向链路速率调度

实施本发明的反向链路调度方法的流程图如图 7 中所示。调度处理中的第一个步骤是步骤 200，它包含在远端站 6 处收集用于每一预定用户的数据传输速率的最佳分配所必须的合适的信息。合适的信息可以包括预定和非预定的任务数、每一远端站 6 的发射功率、表示要由每一远端站 6 传送的数据量的队列大小、基站 4 处用于每一远端站 6 的 $E_b/(N_o+I_o)$ 设置点和测得的 $E_b/(N_o+I_o)$、在前一预定时间内用于每一远端站 6 的非预定任务的传输速率、列举远端站 6 与之进行通信的小区的每一远端站 6 的工作成员组、远端站 6 的优先顺序、以及前一预定时间内每一小区内接收的总功率。下面详细讨论这些参数中的每一个参数。在从每一小区收集到信息以后，信道调度程序 12 根据收集的信息、上述一组目标以及将在下面步骤 202 描述的系统限制表，分配用于每一预定用户的最大预定传输速率。信道调度程序 12 在步骤 204 向每一远端站发送含有最大预定传输速率的调度信息。在预定个数的帧以后，数据由远端站在已经分配给远端站 6 的最大预定传输速率下或在低于最大预定传输速率的速率下发送的。接着，信道调度程序 12 在步骤 206 处等待，直到在下一个调度时间内重新开始调度循环。

最大预定传输速率的分配可以由至少两个实施例来完成。在第一个实施例中，信道调度程序 12 向每一预定用户分配最大预定传输速率。而在第二个实施例中，预定用户请求最大预定传输速率。

在第一个实施例中，图 7 中流程图的步骤 202 中预定用户的最大预定传输速率的分配由图 8 中的流程图进一步给出其描述。信道调度程序 12 分配用于每一远端站 6 的预定任务的最大预定传输速率，从而实现上述目标。在分配传输速率时，信道调度程序 12 满足下面的系统条件：(1)远端站 6 发射功率一远端站 6 处必须具备在最大预定传输速率下进行发射所需的功率；(2)小区接收的功率一每一小区接收的总功率必须不超过预定的阈值，从而对远端站 6 的干扰不过分；(3)软切换一软切换时最大预定传输速率对于支持远端站 6 的所有小区是相同的。(4)远端站 6 的队列规模一高传输速率仅分配给具有充分的要发射的数据量的远端站。下面讨论这些限制中的每一个限制。

在典型实施例中，在每一调度周期开始前的某一段时间内，每一远端站 6 的发射功率与队列规模(queue size)一起发送到信道调度程序 12，并且可以被当作是最大预定传输速率的分配。如果该信息不是用于信道调度程

序 12 的，那么速率的分配是在不考虑远端站 6 的发射功率的情况下进行的。

在收集了对预定用户进行的数据传输速率的最佳分配所必须的合适信息以后，信道调度程序 12 介入图 8 所示的流程图。信道调度程序 12 在状态 210 处开始。第一个步骤是，在步骤 212 处由信道调度程序 12 计算 CDMA 网中每一小区的总容量。每一小区预定传输的总容量计算如下：

$$Q_{avail} = 1 - \frac{P_r}{P_{max}} \tag{1}$$

这里，Q_{avail} 是预定传输的反向链路容量，P_r 是来自非相同小区预定任务的小区处的接收功率，而 P_{max} 是小区处最大允许总接收功率。在小区处接收的非来自同一小区预定任务的功率包括背景热噪声功率 N_oW、来自相邻小区中的远端站 6 的功率 P_{adj}，以及来自同一小区的远端站 6 的用于非预定任务的功率 $P_{unscheduled}$。

分配数据传输速率时信道调度程序 12 需要满足的等式是：

$$\sum \hat{\gamma}_i \frac{R_i}{W} \le 1 - \frac{\hat{P}_r}{P_{max}} \tag{2}$$

这里，$\boxed{\hat{\gamma}_i}$是即将到来的调度周期的第 i 个远端站的预计的 $E_b/(N_o+I_o)$ 设置点，而 R_i 是分配给第 i 个远端站的数据传输速率，W 是系统扩展带宽，而$\boxed{\hat{P}_r}$是非来自同一小区预定任务的用于即将到来的调度周期的小区内预计的接收功率。对于一个 IS-95A 系统，W 是 1.2288MHz。

下面详细描述等式(2)的导出和等式(2)中每一项的意义。等式(2)右边每一项的数量是可以计算得到或者是已知的。等式(2)右边的数量是在每一调度周期开始时对网络中的每一小区一次计算得到的。

预定传输的容量 Q_{avail} 可以用等式(1)以外的其他方法定义或计算。另外，可以通过控制非预定任务的传输来影响 Q_{avail}。例如，通过限制一个或多个远端站 6 的传输速率以降低 P_r，信道调度程序 12 可以增加 Q_{avail}。也可

以考虑采用定义和计算 Q_{avail} 的其他方法，这些方法也包括在本发明的范围内。

注意，除非特指，本说明书中所有等式中所使用的项是以线性标度给出的(而不是以 dB 方式给出的)。还要注意，没有额外标记(如 E_{bi})的符号代表即将到来的调度周期的实际值，用下划线标记的符号(例如 $\underline{E}_{bi}$)代表先前调度周期的已知值或测量值，而带有小帽标记的符号(例如 $\hat{E}_{bi}$)代表即将到来的周期的预计值。

在等式(2)的左面，假设预定用户用于调度周期的预计设置点 γ_i 是与先前的调度周期的设置点 $\underline{\gamma}_i$ 是相同的。所以，在预计了小区已有的容量和特定远端站 6 的设置点以后，信道调度程序 12 能够确定可以由该特定远端站 6 的小区所支持的最大传输速率。

随后，在步骤 214，信道调度程序 12 产生所有预定用户的优先顺序表。该优先顺序表受许多因素的影响。这些因素将在下文中详细讨论预定用户按照他们的相对优先顺序排列，具有最高优先顺序的预定用户排在表的上部，而优先顺序最低的预定用户排在表的底部。信道调度程序 12 随后按照该优先顺序表进入回路，并向预定用户分配已有的反向链路容量。

传输速率分配回路中的第一个步骤是，信道调度程序 12 在步骤 216 选择具有在优先顺序表中具有最高优先顺序的预定用户。信道调度程序 12 接着识别支持该预定用户的小区。这些小区排列在预定用户工作成员组(active member set)中。如果预定用户处在软切换状态，则支持该用户的每一个小区同时接收该用户所传送的数据。因此，对于工作成员组中的每一个小区，信道调度程序 12 在步骤 218 计算用于该预定用户的最大可支持传输速率。用于每一小区的最大可支持传输速率可以通过将等式(2)右面的量乘以 $W/\underline{\gamma}_i$ 来计算。

远端站 6 还可以向小区发送一个请求的传输速率。请求的传输速率可以基于队列的大小，它表示要传输的数据量、远端站 6 可用的总发射功率、即将到来的调度周期内所需的每位预计的发射能量，远端站 6 补偿功率。请求的传输速率代表远端站 6 可以支持的最大传输速率。下面详细推导这一值。

信道调度程序 12 还可以根据在步骤 222 要由预定用户传送并由队列大

小测得的数据量，推荐一个较佳的传输速率。如果该信息是可以用于信道调度程序 12 的，则还可以使这一较佳传输速率成为用于远端站 6 的发射功率的函数。在本典型实施例中，用于远端站 6 的队列大小和发射功率是在每调度周期开始时从远端站 6 传送到信道调度程序 12 的。使选择的较佳传输速率处在调度时间内发送队列中的数据所需的传输速率，或低于该传输速率。

为了保证分配给该远端站 6 的预定任务的反向链路容量可以由软切换中支持远端站 6 的每一小区支持，信道调度程序 12 在步骤 220 选择最大可支持的传输速率表中的最小传输速率、请求的传输速率和较佳传输速率。选择的最小传输速率定义为该预定用户的最大预定传输速率。在向预定用户分配了传输速率以后，调度程序 12 在步骤 226 处从优先顺序表中去掉该预定用户。随后，在步骤 228 处，更新每一小区的容量，以反映分配给刚刚从优先顺序表中去掉的预定用户的容量 Q_i。容量是通过从工作成员组中每一小区、等式(2)右面的量中减去刚刚分配的计算为 $Q_i = \underline{\gamma}_i \cdot R_i/W$ 的容量来计算的。将更新的容量用于以后的传输速率分配。随后，信道调度程序 12 确定是否已在步骤 230 处向优先顺序表上的所有预定用户分配了一个传输速率了。如果优先顺序表不是空的，则信道调度程序 12 回到步骤 216，并向下一个具有最高优先顺序的预定用户分配一个数据传输速率。重复这一分配环路，直到该优先顺序表不再包含预定用户。如果优先顺序表是空的，那么分配过程在步骤 232 处结束。

在另一个实施例中，反向链路容量的分配还可以通过向预定用户分配容量而不是分配最大预定传输速率来完成。该实施例中，信道调度程序 12 向预定用户分配反向链路容量。分配的容量 Q_i 选择通向选择器元件 14 的路由，该选择器元件 14 根据分配的容量和预定用户的设置点(例如，$R_i = Q_i \cdot W/\underline{\gamma}_i$)来计算最大预定传输速率。该实施例中，选择器元件 14 可以根据预定用户的设置点的变化，分配调度周期每一帧处预定用户的新的最大预定传输速率。这使得选择器元件 14 能够通过将干扰保持在一个可接受的水平上来保持反向链路上预定的和非预定任务的通信质量。当然，也可以采用也落在本发明的范围内的其他分配反向链路质量的实施例。

不采用环路，也可以将每一小区的容量分配给预定用户。例如，可以按照加权函数来分配已有的反向链路容量。加权函数可以通过预定用户的优先顺序和、或某些其他的因素来得到。

优先顺序表决定了反向链路容量对预定用户的分配。与具有较低优先顺序的预定用户相比，具有较高优先顺序的预定用户所分配的容量更高。尽管最好根据预定用户的优先顺序按顺序分配容量，但这并不是一个必要的限制。可以用任何一种顺序来分配已有的资源，这种方法同样落在本发明的范围内。

本发明的反向链路速率调度可以连续、周期地或以交错方式来进行。如果调度是以连续或周期的方式进行的，那么应当选择调度时间，使得在调度周期内小区的反向链路容量能够得到完全的利用。这一目标可以通过下面的实施例来实现。当然，也可以采用下述实施例的变化方式或组合。这些变化形式或组合同样也落在本发明的范围内。

在第一个实施例中，调度(或容量分配)是在每一帧中进行的。这一实施例使得信道调度程序 12 在每一帧中动态地调节预定用户的最大预定传输速率，从而完全利用网络中每一小区已有的容量。在每一帧中分配最大预定传输速率还需要进行更多的处理。同时，在每一帧中向每一预定用户发送必要的调度信息需要更多的额外花费。另外，还可以要求远端站 6 向信道调度程序 12 更经常地提供有关其当前发射功率、其最大发射功率以及其容量的信息。

在第二个实施例中，调度是每 K 个帧进行一次。这里，K 是大于 1 的整数。对于每一个调度时间间隔，信道调度程序 12 分配用于每一预定用户的最大预定传输速率。在典型的实施例中，可以在等式(2)中用高 P_{max} 值，来计算最大预定传输速率。另外，可以用比前一个调度周期的设置点 $\underline{\gamma}_i$ 低的设置点值，来计算最大预定传输速率。将结果通知给被调度的用户。在典型的实施例中，每一调度周期一次，将最大预定传输速率的调度通知给调度的用户。如下面讨论的那样，在以后的几个预定的帧中，将出现在高速传输速率下进行的数据传输。在调度周期时间内，由信道调度程序 12 来分配预定任务的最大预定传输速率。在调度周期时间内，如果小区的容量不是在最大的预定传输速率下支持数据传输，则信道调度程序 12 可以在较低的传输速率下来指挥数据传输。

在预定时间内，允许每一远端站 6 在直至其最大预定传输速率的速率下进行发送。如果远端站 6 不能够在最大预定传输速率下进行发送，则远端站 6 可以在较低的传输速率下向小区通知数据传输。随后，远端站 6 同时或

随后不久，在更低的传输速率下发送数据。与此类似，如果这些小区的反向链路容量不是在最大预定传输速率下支持数据传输，则信道调度程序 12 在更低的传输速率下指挥数据传输。

有几个原因使得第二个实施例比第一个实施例更好。在反向链路上，从将数据提供给远端站 6 的时刻到在高速传输速率下进行数据传输的时刻，存在着调度延迟。在典型的实施例中，调度延迟在长度上可以多达七个帧。调度延迟影响信道调度程序 12 对反向链路容量和要求变化的响应性。当反向链路的负荷较轻的时候，使远端站 6 能够在任何一种速率下直至在最大预定传输速率下进行发送减小了调度延迟。当远端站 6 没有更多要发送的数据时，远端站 6 能够立即减小传输速率，所以，就减小了反向链路对其他远端站 6 的干扰。另外，信号处理和发射功率资源不会象在远端站 6 处那样在小区内受到限制。所以，小区可以在最大预定传输速率下进行解调，而不会以损害其主要的性能为代价。

第二个实施例还具有的优点是，在向预定用户发送最大预定传输速率的时间表(schedule)时需要的开销较低。在第一个实施例中，调度信息是在每一个帧内发送到预定用户的。一部分前向链路资源因此而得到这一部分的开销。在第二个实施例中，调度信息是每一调度周期一次传送到预定用户的。例如，如果调度时间是 10 个帧，则第二个实施例需要略多于第一个实施例中的 1/10 的开销，但仍然能保持反向链路有效的利用率。下面将要讨论的传输速率再分配，使得可以在调度周期内的每一个帧内进行，从而信道调度程序 12 能够在每一个帧内动态地再分配传输速率。发送临时传输速率的时间表(schedule)所必须的附加开销是最小的。这是因为在每一帧内只有一部分的预定用户的传输速率是再分配的。事实上，只有再分配足够的预定用户，才能使网络中所有的小区在低于小区总的反向链路容量的容量下运作。

另外，在第三个实施例中，可以使反向链路速率调度交错。该实施例中，调度可以因某些事件而启动。例如，无论是接收到高速数据传输请求，还是完成由远端站 6 进行的预定的高速数据传输，信道调度程序 12 都能够进行反向链路速率调度。信道调度程序 12 知道要由每一远端站 6 传送的数据量和最大预定传输速率。通常，除了处在衰减环境(例如，缺少发射功率)中的情况下，远端站 6 在最大预定传输速率下进行发射。所以，信道调度程序 12 能够确定是何时完成高速数据传输的。在结束了由远端站 6 进行的预

定传输以后，信道调度程序 12 能够进行调度，并向其他的远端站 6 分配反向链路容量。最大预定传输速率的时间表(schedule)仅传送到已经分配或再分配了传输速率的远端站 6。

反向链路速率调度可以由 CDMA 网中所有小区的信道调度程序 12 进行。这一实施例能够使信道调度程序 12 有效地对处于软切换下并且正与多个小区进行通信的远端站 6 进行高速数据传输的调度。由于小区与远端站 6 之间的各种相互作用，整个网络的调度更为复杂。在另一种实施例中，为了使调度简化，可以将预定任务分成两种类型，来自处于软切换的远端站 6 的预定任务和不处于软切换的远端站 6 的预定任务。该实施例中，可以在小区的水平上进行对仅与一个小区进行通信的远端站 6 的反向链路速率调度。与多个小区进行通信的远端站 6 可以由信道调度程序 12 进行预定。本发明还可以应用于前向链路速率调度的实施例，包括集中式调度、分布式调度及其任何一种组合。

II. **传输速率再分配**

在上述第一个实施例中，反向链路速率调度是每一个帧中都进行的，反向链路容量可以在调度周期内再分配，以使反向链路要求符合可用的容量。尽管容量是在每一个帧中都进行分配的，但调度延迟可以产生次最佳的(sub-optimal)容量分配。在调度延迟期间，系统的状态可能已经发生了变化。同时，初始预告可能也不准确，也需要作修正。

在第二个实施例中，调度是每 K 个帧进行一次，传输速率可以在调度周期内再分配，以使反向链路要求符合现有的反向链路容量。在本典型实施例中，数据传输是发生在调度周期的最大预定传输速率下或低于该最大预定传输速率的情况下，无需采用传输速率再分配子程序 (rourine)。这简化了调度子程序，但可能会导致较低的 $E_b/(N_o+I_o)$，而使通信质量降低。本较佳实施例中，可以每一帧再分配一次最大预定传输速率，以保持通信质量。

在调度周期内，如果小区的反向链路容量不支持最大预定传输速率下的数据传输，则信道调度程序 12 在更低的传输速率下指挥数据传输。对于小区的反向链路容量不适合于服务预定和非预定任务的要求的每一个帧，信道调度程序 12 决定反向链路要求的增加量和可用的反向链路容量。随后，信道调度程序 12 分配用于一些或全部预定用户的较低的传输速率，使得用户要求的容量不超过小区的总的容量。在本典型的实施例中，较低的传输速

率称为临时的传输速率并仅对一帧应用。对于调度周期中以后的帧，采用最大预定传输速率，除非由信道调度程序 12 作出修改。

信道调度程序 12 还可以通过增加小区可用的总容量，来尝试使速率再分配为最小。增加总容量可以通过降低非预定用户的传输速率(例如，将话音用户的传输速率限制在更低的速率下)来实现。

本典型实施例中，传输速率的再分配是在每一个帧内进行的，从而确保每一小区的预定和非预定任务所需的容量小于小区现有的总反向链路容量。临时传输速率的时间表(schedule)传送到已经再分配的临时传输速率的预定用户。对于每一个帧，预定用户验证还没有再分配传输速率。在调度周期中的每一个帧内，每一预定用户在最大预定传输速率下或低于该最大预定传输速率下或在临时传输速率下发送数据。

传输速率再分配由图 9 中所示的流程图描绘。信道调度程序 12 在状态 240 处开始。在第一个步骤中，在步骤 242 处，信道调度程序 12 产生网络中的小区表，其中，预定和非预定任务所需的反向链路容量超过小区的现有总容量。信道调度程序 12 在步骤 244，用等式(2)，计算 CDMA 网中每一个小区的现有总反向链路容量。接着，信道调度程序 12 产生正与小区表中的至少一个小区进行通信并已在步骤 246 处被分配了一个当前调度周期的传输速率的所有预定用户的优先顺序表。优先顺序表中的预定用户称为受影响的预定用户。随后，信道调度程序 12 进入环路，并按照优先顺序表和小区表，再分配一些或全部受影响的预定用户的传输速率。

在传输速率再分配环路内的第一个步骤中，信道调度程序 12 在步骤 248 处选择具有最高优先顺序的受影响的预定用户。随后，信道调度程序 12 识别支持高速数据传输的受影响的预定用户的小区。这些小区称为选择的小区。接着，信道调度程序 12 在步骤 250，由每一选择的小区计算受影响的预定用户的最大可支持传输速率。为了保证可以由每一选择的小区提供分配给该预定用户的反向链路容量，信道调度程序 12 在步骤 252 处，从最大可支持传输速率和最大预定传输速率的表中选择最小传输速率。选择的最小传输速率定义为临时传输速率。在本典型实施例中，临时传输速率低于最大预定传输速率，并且仅在步骤 254 处分配给即将到来的帧的预定用户。在步骤 256 处，从优先顺序表中去掉受影响的预定用户。随后，在步骤 258 处，更新每一选择的小区已有的总反向链路容量，以反映分配给刚刚从优先顺序表

中去掉的受影响的预定用户的容量。接着，在步骤 260 处，信道调度程序 12 更新小区表，并去掉总反向链路容量为零的小区。随后，信道调度程序 12 在步骤 262 处判断小区表是否空了。如果小区表没有空，则信道调度程序 12 在步骤 264 处判断优先顺序表是否空了。如果优先顺序表没有空，则信道调度程序 12 回到步骤 248，并向具有下一个最高优先顺序的受影响的预定用户再分配一个数据传输速率。传输速率再分配环路一直进行下去，直到小区表或优先顺序表空了为止。如果小区表或优先顺序表空了，则传输速率再分配过程在状态 266 处结束。

如果小区表处的 FER 较高，或者如果测得的总接收功率 $P_{总}$高于预定的阈值，则信道调度程序 12，选择器元件 14 或小区还可以临时向远端站 6 分配更低的传输速率。临时传输速率可以被立即发送到远端站 6，而不必等待下一个调度周期，并且在临时传输速率下的数据传输可以立即或者在随后不久出现。这就减小了处理延迟，并使得信道调度程序 12 或小区能够立即行动，提高反向链路上的通信质量。

最大预定传输速率代表信道调度程序 12 允许远端站 6 发送最高达最大预定传输速率。远端站 6 可以在更低的传输速率下发送。如果远端站 6 判断其现有的发射功率是不支持在最大预定传输速率下的数据传输的，则远端站 6 可以向正与远端站 6 进行通信的所有小区发送一条减小速率的消息。减小速率的消息表示远端站 6 想要采用的更低的传输速率。在本典型实施例中，远端站 6 在传送减小速率的消息的同一帧内，或在随后的预定个数的帧内，在更低的传输速率下发送。使远端站 6 能够单方面地降低传输速率而不必由信道调度程序 12 再分配，减小了处理延迟，并且提高了反向链路上的通信质量。由于已经分配了反向链路容量，远端站 6 最好在最大预定传输速率下发送。较低传输速率下的数据传输会导致反向链路容量的利用不充分。

另一种情况是，如果远端站 6 判断现有的发射功率支持在更高传输速率下的数据传输，并且队列较大，则远端站 6 可以请求在调度周期中提高速率。更高传输速率的请求可以在软切换中传送到支持远端站 6 的所有小区。如果有任何一个小区判断该小区的反向链路容量满了，则忽略该更高传输速率的请求。反之，该请求将会迂回到(routed)信道调度程序 12，该信道调度程序 12 会考虑调度周期中的请求。

III. 远端站发射功率考虑

每一远端站6受到它可用的最大发射功率的限制。最大发射功率是由FCC规则、电池容量以及对 CDMA 网中的其他远端站 6 的干扰的限制。远端站 6 要求每位 E_{bi} 的能量来将数据发送到小区，以用于必要的性能水平。对于话音通信，1%FER 是一个合适的性能水平，但对数据通信的要求更严格。应当由每一远端站 6 满足的功率限制是：

$$\boxed{E_{bi} \cdot R_i < P_{max,\ i}} \tag{3}$$

这里，

E_{bi}＝第 i 个远端站所要求的每位发射能量，

R_i＝第 i 个远端站的传输速率，以及

$P_{max,\ i}$＝第 i 个远端站所可用的最大发射功率。

在反向链路上，对于每一远端站 6，在小区处测得的每位能量与噪声加上干扰的比值 $E_b/(N_o+I_o)$ 受到控制，从而保持所必须的性能水平，并且同时使远端站 6 的发射功率为最小。由于每一远端站 6 的发射功率是对 CDMA 网中其他远端站 6 的干扰，所以在反向链路上，该功率控制是决定性的。使发射功率为最小减小了干扰，并提高了反向链路容量。

当远端站 6 在网络周围移动时，多径和衰落的影响显著改变了小区处接收的信号的 $E_b/(N_o+I_o)$。事实上，接收的 $E_b/(N_o+I_o)$ 的动态变化可以在通信中大于 60dB。为了克服这种大范围的变化，每一远端站 6 保持动态调节发射功率的功率控制机构，以克服信道条件的变化。对于符合 IS-95A 标准的 CDMA 系统，每一远端站 6 允许有一个 60dB 的范围用于反向链路功率控制，并且发射功率可以增加或降低每 1.25 秒 1dB。

远端站 6 的发射功率从最大发射功率得到补偿，以保持一定的峰值储备 (headroom)。该峰值储备使得远端站 6 的功率控制机构能够调整发射功率，以克服信道条件的变化，并且适应于非预定任务的传输速率的变化。所以，等式(3)可以表述为：

$$E_{bi} \cdot R_i < \alpha \cdot P_{max,i} \tag{4}$$

这里，α 是接收用于补偿的一部分发射功率。例如，如果接收到的最大发射功率的一半用于补偿，则 α ＝0.5(3dB 的补偿功率)。所要求的每位的能量 E_{bi} 可以是来自发射功率 $\underline{P}_i$，而用于前一调度周期的传输速率 $\underline{R}_i$ 如下：

$$\hat{E}_{bi} = \frac{P_i}{\underline{R}_i} \cdot \delta(\underline{R}_i, R_i) \tag{5}$$

E_{bi} 是即将到来的调度周期所要求的预计的(predicated)每位的能量，而 $\delta(\underline{R}_i, R_i)$ 是在前一传输速率 $\underline{R}_i$ 和预定传输速率 R_i 具有不同要求的每位能量时所要使用的校正因子。帧误差率(FER)还可以是考虑到对要求的每位能量的预计。具体说来，预计的每位能量可以在 FER 较高时增加，或者在 FER 较低时降低。所以，等式(5)变成：

$$\hat{E}_{bi} = \frac{P_i}{\underline{R}_i \cdot f(Pe)} \cdot \delta(\underline{R}_i, R_i) \tag{6}$$

这里，Pe 是 FER，而 f(Pe)是 Pe 的函数。f(Pe)可以用一个等式来表示，或者是一个查询表。通常，f(Pe)为正值，并随 Pe 的降低而增大。将等式(4)和(6)合并，可以根据现有的发射功率分配给远端站的最大传输速率、补偿功率以及预计的远端站 6 所需的每位能量就变成为：

$$R_{\max,i} = \frac{P_{\max,i} \cdot \alpha}{\hat{E}_{bi}} \tag{7}$$

等式(7)可以在远端站 6 处计算，而最大传输速率 $R_{\max}$ 可以与队列大小一起由远端站 6 用来确定请求的传输速率。另外，远端站 6 可以将最大发射功率 $P_{\max,i}$、预计要求的每位能量 E_{bi} 以及队列大小传送到信道调度程序 12，用于在向远端站 6 分配传输速率时考虑。

IV. 反向链路容量

CDMA 系统中反向链路的容量主要由每一远端站 6 对其他远端站 6 产生的干扰决定。这是因为每一远端站 6 在系统带宽上对数据进行扩展，并在同一频带上发送信号。小区接收所有远端站 6 发送的功率，并解调每一远端站 6 的信号。小区从 M 个远端站 6 接收的总功率，对于预定的非预定的任务，可以表述成：

$$P_{total} = P_r + \sum_{j=1}^{M} P_j \qquad (8)$$

这里，

P_{total}＝小区接收的总功率，

P_r＝不是从同一小区预定任务接收的功率，

P_i＝从第 i 个远端站的预定任务接收的功率，以及

M＝传送预定远端站的个数。

给定远端站 6 的 $E_b/(N_o+I_o)$ 由下式给出：

$$X_i = \frac{E_{bi}}{N_o + I_o} = \frac{W}{R_i} \bullet \frac{P_i}{P_r + \sum_{j \neq i}^{M} P_j} \qquad (9)$$

E_{bi}＝第 i 个远端站的每位能量，

N＝系统的背景噪声密度，以及

I_o＝对由系统中的其他来源从第 i 个远端站接收的信号的干扰。

每一远端站 6 对必要的性能水平要求不同的 $E_b/(N_o+I_o)$。事实上，特定的远端站 6 在与小区的通信期间的不同时候，可以需要不同的 $E_b/(N_o+I_o)$。影响要求的 $E_b/(N_o+I_o)$ 的主要因素是信道条件。例如，远端站 6 在 CDMA 网周围移动的速度会影响衰落，因此也影响信道状态。低速的情况下，功率控制机构能够抵消慢衰落，并且要求的 $E_b/(N_o+I_o)$ 较低。高速的情况下，功率控制不能抵消快衰落，并且交错的效果越来越有利。在中速的情况下，由于无论是功率控制还是交错都是无效的，所以要求的 $E_b/(N_o+I_o)$ 最高。其他的因素也会影响信道条件的效果，因此也会影响要求的 $E_b/(N_o+I_o)$。

将等式(8)和(9)合并，并用等式(8)中的求和项来近似等式(9)带分母中的求和项，得到：

$$P_{total} = \frac{P_r}{1 - \sum_{i=1}^{M} X_i \frac{R_i}{W}} \qquad (10)$$

总接收功率 P_{total} 与反向链路容量相关的程度是很高的。等式(10)分母中的项 $\sum X_i \frac{R_i}{W}$ 与系统的负载相关。等式(10)中，当 $\sum X_i \frac{R_i}{W}$ 接近 1.0 时，P_{total}

接近为无限大，这是系统所无法达到的工作点。反向链路更高的负载将导致更高的干扰水平。更高水平的干扰迫使远端站 6 在更高的功率下进行发射，以保持所必须的性能水平。由于每一远端站 6 的发射功率有一个上限，所以 P_{total} 的上限受到限制，以保证非预定任务的覆盖范围。P_{max} 的工作点依赖于系统的设计，并且与小区边界处的远端站 6 的可实现的 $E_b/(N_o+I_o)$ 相关。$E_b/(N_o+I_o)$ 直接与 FER 特性相关。工作在更高负载下会导致覆盖区边界处非预定用户更糟的 $E_b/(N_o+I_o)$，因此也将导致更高的 FER。

在典型的实施例中，小区含有两个用于每一远端站 6 的功率控制环路，以保持必要的 FER 特性水平，同时使对其他远端站 6 的干扰最小。第一个功率控制环路，称为内环路，调整远端站 6 的发射功率，使得在设置点处保持在小区处接收的由 $E_b/(N_o+I_o)$ 测得的信号质量。小区测量接收的信号的 $E_{bi}/(N_o+I_o)$，并向远端站 6 发射一个控制信号，指令远端站 6 在测得的 $E_b/(N_o+I_o)$ 低于设置点时使发射功率增加 1dB 的步进增量。小区也可以在测得的 $E_b/(N_o+I_o)$ 高于设置点时指令远端站 6 降低发射功率。内环路调整远端站的发射功率，使得发射功率为最小，并且同时使测得的 $E_b/(N_o+I_o)$ 保持与设置点相等。第二个功率控制环路称为外环路，调整设置点，使得保持由帧差错率(FER)测得的要求的性能水平。如果测得的 FER 高于预定的水平，则小区提高设置点。相反，如果 FER 低于预定的水平，则小区降低设置点。为了保持两个环路之间的平衡，使外环路的时间常数小于内环路的时间常数。另外，远端站 6 可以采用开放式环路功率控制系统，按照所接收的前向链路信号功率的变化调整发射功率。

信道调度程序 12 分配用于每一远端站 6 的预定任务的数据传输速率，并同时保持 P_{total}，使其小于 P_{max}。可以采用用于前一调度周期 $\chi_i = \underline{\gamma}_i$ 的远端站 6 的设置点 $\underline{\gamma}_i$ 来预计远端站 6 所要求的 $E_{bi}/(N_o+I_o)$ 或 χ_i。由于外环路将设置点保持在产生所要求的性能水平的设置下，所以设置点能够很好地预计所要求的 $E_{bi}/(N_o+I_o)$。

在某些极端的场合，设置点不能作为所需 $E_{bi}/(N_o+I_o)$ 的良好估计。在第一种情况下，远端站 6 在最大的发射功率下发射，但 FER 仍然很高。这时，远端站 6 处于与多个小区的软切换状态，并且每一小区测得一个不同的 $E_b/(N_o+I_o)$。为了使对系统中其他远端站 6 的干扰为最小，如果小区指令远

端站 6 降低功率，则远端站 6 降低发射功率。所以，对于具有更弱反向链路的小区，测得的 $E_b/(N_o+I_o)$ 低于设置点。并且在第三种状态中，当前的传输速率和预定的传输速率具有不同的所需 $E_b/(N_o+I_o)$。

当测得的 $E_b/(N_o+I_o)$ 低于设置点时，小区处的 FER 可能较高。在这种状态下，内功率控制环路试图增加发射功率，使测得的 $E_b/(N_o+I_o)$ 保持在设置点。如果失败，而且出现过高的 FER，则信道调度程序 12 认为信道状况恶化，并且可以使远端站 6 处于保持状态，直到信道状况改进为止。

小区不是从同一小区预定任务接收的功率 P 可以由一个或多个前调度周期的测量来预计，其方法是，如下等式所述，从小区接收的总功率减去预定任务的接收的功率：

$$\hat{P}_r = \underline{P}_{total}\left(1-\sum_{i=1}^{M}\underline{\gamma}_i \frac{R_i}{W}\right) \tag{11}$$

这里，$\hat{P}_r$ 是小区在即将到来的调度周期中不是从同一小区预定任务处接收的预计接收功率，而 P_{total} 是在前一调度周期内小区接收的总功率。$\hat{P}_r$ 也可以从其他的系统测量来预计。通过用等式(11)中的 $\hat{P}_r$ 来替换等式(10)中的 $\hat{P}_r$，并整理各项，反向链路的容量可以表述成：

$$\sum_{i=1}^{M}\gamma_i \frac{R_i}{W} \le 1 - \frac{\underline{P}_{total}}{P_{\max}}\cdot\left(1-\sum_{i=1}^{M}\underline{\gamma}_i \frac{R_i}{W}\right) \tag{12}$$

等式(12)表示，可以从先前的调度周期的信息来确定现有的反向链路容量(例如可以分配用于即将到来的调度周期的数据传输速率)。等式(12)右边的项表示即将到来的调度周期的可用的反向链路容量，并且是基于来自前一调度周期的信息的。

在分配预定任务的数据传输速率时，P_{max} 的值可以用来调整要调度到远端站 6 的总反向链路容量。P_{max} 可以按照统计的 P_{total} 或统计的 FER 来调整。例如，如果平均的 FER 增加，或平均的 P_{total} 太高，则信道调度程序 12 可

以减小即将到来的调度周期内的 P_{max}，从而使反向链路在较低的负载下工作，以改良 FER。

V. 软切换

CDMA 网中所有远端站 6 可以处于在小区间进行软切换的状态。处于软切换状态下的每一远端站 6 同时与两个或多个小区进行通信。在 CDMA 系统中采用软切换详见上述美国专利 5,267,261。

在软切换状态下向远端站 6 分配最大预定传输速率时，信道调度程序 12 确保参加软切换的每一个小区满足等式(2)的限制。在每一调度间隔开始时，选择器元件 14 向信道调度程序 12 发送 CDMA 网中每一远端站 6 的工作成员组。工作成员组包含与远端站 6 进行通信的小区表。对于工作成员组中的每一个小区，信道调度程序 12 计算可以由小区支持的最大传输速率。来自工作成员组的所有小区的最大可支持的传输速率形成一个可能的数据传输速率的列表。由于对所有的小区来说，等式(2)是必须满足的，所以来自最大可支持传输速率的表的最小数据传输速率对于所有的小区，满足等式(2)的限制。所以，可以分配给特定远端站 6 的最大传输速率是最大可支持传输速率表中的最小值。

VI. 数据队列规模

在分配最大预定传输速率时，考虑远端站 6 的队列大小。队列大小表示要由远端站传送作为远端站 6 接收数据的时间的数据量。在每一调度周期开始时，所有预定任务的队列大小被发送到信道调度程序 12。信道调度程序 12 按照该队列大小分配高速传输速率。例如，信道调度程序 12 只有在队列大小在预定的阈值以上时才分配高速传输速率。另外，如果队列大小的变化速率在另一个预定的阈值以上时，信道调度程序 12 可以分配一个高速传输速率。另外，如果远端站 6 的队列大小接近最大队列规模时，信道调度程序 12 可以分配一个高速传输速率。为此，信道调度程序 12 可以帮助接近其存储容量极限的远端站 6。

在本典型实施例中，信道调度程序 12 分配最小传输速率，使得可以在 K 个帧调度周期中传送队列中的数据。如果队列规模较小，则由于少量的数据可以在分配给与小区进行通信的每一远端站 6 的最大非预定传输速率下传送，所以信道调度程序 12 忽略这一任务。

调度延迟存在于从远端站具有数据的时刻到在高速传输速率下进行实

际数据传输的时刻。调度延迟是因处理延迟而产生的，在本典型实施例中，可以是七个帧的时间长度。本典型实施例中，在每一调度周期开始时，将队列规模传送到信道调度程序 12。信道调度程序 12 调整队列规模，以适应调度延迟期间队列规模可预计的变化。具体说来，在调整队列规模时，考虑调度延迟期间传送到小区的数据和在调度延迟期间已知到达的新数据。另外，还考虑到队列规模预计中要传送的数据。

调度延迟期间传送的数据量可以通过将用于调度延迟中的每一个帧的分配给远端站 6 的最大预定传输速率相加来预计。这是对队列大小进行的精确性适度的调整，这是因为在大多数情况下，远端站 6 在最大预定传输速率下进行发射的。如果远端站 6 在更低的传输速率下进行发射，例如可以是因为不合适的发射功率，则实际的队列大小可以大于调整的队列大小。队列中附加数据的传输可以在后续的调度周期内被调度。

参见图 10，在帧 k 处，远端站 6 测量要传送的数据的队列大小。在帧 k+1 处，远端站 6 将队列大小发送到信道调度程序 12。由于调度延迟，信道调度程序 12 知道在帧 k+7 之前，不会发生在高速传输速率下进行的数据传输。信道调度程序 12 还知道队列中的某些数据是在调度延迟期间传送的，即在帧 k+1 和帧 k+6 之间的时间内传送的。调度延迟期间的数据传输是在分配到帧 k+1 到 k+6 的最大预定传输速率下或低于该速率的速率下进行的。所以，当接近帧 k+7 时通过减去要在帧 k+1 到帧 k+6 期间传送的数据量，信道调度程序 12 调整队列的大小。信道调度程序 12 知道将在帧 k+1 和 k+6 之间到达远端站 6 的数据被加到计算的队列规模上。

VII. 高速数据传输

可以将本发明的反向链路速率预定方法和装置用于能够进行可变速率数据传输的通信系统。例如，可以将本发明用于 CDMA 系统、GLOBALSTAR 系统、时分多址(TDMA)系统或频分多址(FDMA)系统。本发明也可以应用于 CDMA 系统或其他的可变速率通信系统，这些系统采用单个的可变速率信道，或多个具有固定速率的信道，或者是可变速率信道与固定速率信道的组合的原理。这些应用也是在本发明的范围内的。

在第一个实施例中，在单个的可变速率信道上出现的是高速数据传输。在向小区始发呼叫期间，远端站 6 在可变速率信道上分配有 1(或 9.6Kbps)的最大非预定传输速率。所以，远端站 6 可以在直到 1 的任何一个速率(包

括 1、1/8、1/4、1/2 和 1)下发送非预定传输。除非信道调度程序 12 的允许，否则不允许远端站 6 在更高的传输速率下进行发送。本说明书中，以这种方式使用的可变速率信道也称为业务信道。对于高速数据传输的情况，可以向远端站 6 分配一个大于 1 的最大预定传输速率。随后，对于高速数据传输，远端站 6 可以在更高的数据速率下，直到最大的预定传输速率下进行发射。

在第二个实施例中，在多个信道下出现高速的数据传输，在后文中称为业务信道和第二编码信道(secondary code channel)。在与小区建立起呼叫期间，业务信道被分配给每一个远端站 6，并且业务信道使得能够在直到 1 的最大非预定传输速率下进行非预定传输。第二编码信道可以是固定的或可变速率信道。高速数据传输中使用的第二编码信道的概念和实施详见标题为“前向链路速率预定的方法和装置(METHOD AND APPARATUS FOR FORWARD LINK RATE SCHEDULING)”、申请日为 1997 年 2 月 11 日的美国专利申请 08/798,951，该专利申请已转让给本发明的受让人，在此引述供参考。

本典型实施例中，信道调度程序 12 使最大预定传输速率等于一组第二编码信道。远端站 6 用来在分配的第二编码信道上发送数据。分配的第二编码信道的标识在三个实施例中的一个实施例中被传送到远端站 6。在第一个实施例中，每一个第二编码信道的标识在每一个调度周期内被传送到远端站 6。这需要更多的开销，但却具有最大的灵活性。

在第二个实施例中，将第二编码信道分成信道组，每一个信道组用特有的第二编码信道编组来标识。在与小区通信的呼叫建立阶段或在软切换的呼叫建立阶段，将信道组的定义传送到远端站 6。信道调度程序 12 分配最大的预定传输速率，并选择一个与最大预定传输速率相应的信道组。将信道组的标识传送到远端站 6。由于本实施例中仅将信道组的标识而不是每一个第二编码信道的标识传送到远端站 6，所以本实施例与第一个实施例相比需要较少的开销。

第三个实施例是第二个实施例的子集(subset)。每一个信道组由一个沃尔什码定义，并且信道组的个数 N 是由第二编码信道 1 到 N 组成的。使分配的传输速率等于沃尔什码，并且将该沃尔什码传送到远端站 6。更高的传输速率与更多的第二编码信道和更高的沃尔什码相等。远端站 6 在与沃尔什码相关的所有第二编码信道上传送数据。例如，沃尔什码 5 与第二编码信道

1 到 5 相等。沃尔什码 5 的分配表示远端站 6 可以在第二编码信道 1 到 5 上发送数据。如果远端站 6 决定在更低的传输速率下例如采用三个第二编码信道进行发送，则远端站 6 将沃尔什码 3 发送到小区，表示想要在第二编码信道 1 到 3 上进行发送。

VIII. 第二编码信道的编码和调制

对于上述第二个实施例，其中高速数据传输出现在第二编码信道上，可以通过下述的实施例来完成反向链路的第二编码信道的编码和调制。其他的实施例可以用来在反向链路的第二编码信道上发送数据。第一个实施例详见上述美国专利申请 08/654,443。下面描述编码器和调制器，已便于理解本发明。

第一个实施例中编码器 72 的典型方框图如图 4 中所示。数据源 70 中包含大量要传送到小区的信息。通过 DEMUX(去多路复用器)102 将这些数据提供到一组 BPSK 和 QPSK 信道编码器 104 和 106。DEMUX102 对从数据源 70 到选择的 BPSK 或 QPSK 信道编码器 104 和 106 的数据进行去多路复用。BPSK 和 QPSK 信道编码器 104 和 106 对数据进行编码和重新排序，并将经编码的数据提供到调制器 74。要选择的信道编码器的类型，即是 BPSK 还是 QPSK，是取决于系统设计的。编码器 72 可以用一组 BPSK 信道编码器 104、一组 QPSK 信道编码器 106 或 BPSK 及 QPSK 信道编码器 104 和 106 的组合来构成。

在 BPSK 信道编码器 104 中，将来自数据源 70 的数据分隔成数据帧，并提供到 CRC 发生器 110。CRC 发生器 110 产生用于数据帧的 CRC 位、插入编码尾位，并将 CRC 编码的数据提供到卷积编码器 112。卷积编码器 112 对 CRC 编码的数据进行卷积编码。本典型实施例中，尽管也可以采用其他条件的长度和速率，但卷积编码器 112 的限制长度是 K=9，并且速率是 1/4。一个 K=9、速率 1/4 的编码器在话音数据的反向链路传输中使用的速率 1/2 和速率 1/3 编码器上提供附加的编码增益。块交错器(block interleaver)114 接收经编码的位，并对这些位进行重新排序，以提供时间分集。该时间分集对由小区接收的突发性差错(burst errors)进行扩展，并提高在小区处维特比译码的性能。

可变起始点重发器 116 接收经交错的数据，并重复每一位 N_B 数次，以提供 307.2Ksps 的恒定的输出码元速率。按照 IS－95A 标准，每一编码信道帧是 20 毫秒长，并且对应于在 307.2Ksps 码元速率下的 6,144 个码元。如

果 N_B 的值不是一个整数，则仅对一部分经编码的数据进行最终的重复。在本典型实施例中，可变起始点重发器 116 采用不同的起始点来开始每一数据帧的重复。将产生的重复码元提供到 BPSK 映射器(mapper)118，产生用于每一重复码元的+1 值或-1 值。

QPSK 信道编码器 106 的功能与 BPSK 信道编码器 104 的功能几乎相同。将来自数据源 70 的数据分隔成数据帧，其路由通过 DEMUX 102，并提供到 CRC 发生器 130。CRC 发生器 130 对数据帧进行分块编码(block encode)，并将 CRC 编码的数据提供到卷积编码器 132。卷积编码器 132 用速率 1/4、K＝9 编码器对经 CRC 编码的数据进行卷积编码，当然也可以采用其他的速率和限制长度。块交错器 134 接收经编码的位，对这些位重新排序，并将经交错的数据提供到可变起始点重发器 136。可变起始点重发器 136 使每一位重复 N_Q 次，以获得 614.4Ksps 的固定的输出码元速率。将重复的码元提供到 QPSK 映射器，将重复的码元分成两组，并产生四种可能的状态中的一种状态，用于同相($QPSK_I$)输出和正交相($QPSK_Q$)输出。例如，(0,0)重复码元的编组可以对应于 $QPSK_I$＝-1，以及 $QPSK_Q$＝-1；(0,1)重复码元的编组可以对应于 $QPSK_I$＝-1，以及 $QPSK_Q$＝+1，等等。$QPSK_I$ 和 $QPSK_Q$ 输出处的码元速率是 307.2Ksps。

在第一种实施例的另一种结构中，将来自数据源 70 的数据直接提供到 CRC 发生器 110，它产生正传送的数据帧的 CRC 位。将 CRC 编码的数据提供到对 CRC 编码数据进行卷积编码的卷积编码器 112。将经编码的位提供到一个块交错器 114，对编码位进行重新排序，以提供时间分集。将经交错的数据提供到一组可变起始点重发器 116 和 136，通过 DEMUX 102，将一个用于每一个 BPSK 和 QPSK 信道编码器 104 和 106。通过将对所有 BPSK 和 QPSK 信道编码器的 CRC 块编码、卷积编码以及块交错与一个 CRC 发生器、一个卷积编码器和一个块交错器为一组结合起来，而使得硬件的需求为最小。

第一个实施例的远端站 6 中调制器 74 的典型方框图如图 5 所示。将从编码器 72 得到的 BPSK、$QPSK_I$ 和 $QPSK_Q$ 输出提供到调制器 74。将每一个 BPSK 输出提供给一个特有的 BPSK 沃尔什调制器 146。在 BPSK 沃尔什调制器 146 中，由乘法器 150 用特有的沃尔什码来调制 BPSK 编码的数据，并由增益调节 160 用一个特有的增益来放大。例如，$BPSK_1$ 输出由沃尔什码 W_1 调制，并由增益 B_1 放大。与此类似，将每一个 $QPSK_I$ 和 $QPSK_Q$ 输出对提供到特有的 QPSK 沃尔什调制器 148。在 QPSK 沃尔什调制器 148 中，由乘法器 152-156 用特

有的沃尔什码对 QPSK 编码数据进行调制，并由增益调节 162-166 用特有的增益进行放大。例如，$QPSK_{I1}$ 和 $QPSK_{Q1}$ 输出对由沃尔什码 W_{M+1} 调制，并用增益 Q_1 进行放大。增益调节 158 接收 PILOT 信号，在本典型实施例中，该信号由与正逻辑电压相关的逻辑电平组成，并按照增益 P 调节幅度。PILOT 信号不含有数据，但提供基站 4 中的 RF 单元 42 可以用来在其余的 BPSK 和 QPSK 信道上对数据进行相干解调的参考载波信号。

用加法器 168a 将沃尔什码调制的以及增益调节的 $QPSK_I$ 信号相加。与此类似，由加法器 168b 将沃尔什码调制的以及增益调节的 $QPSK_Q$ 信号相加，形成信号 X_Q。由加法器 170 将沃尔什码调制的以及增益调节的 BPSK 信号、增益调节的 PILOT 信号以及加法器 168a 输出相加，形成信号 X_I。

后续的信号处理用来用长 PN 码和短 PN_I 和 PN_Q 码作进一步的扩展，并且在 QPSK 调制的信号的同相(I)和正交相(Q)成分上均匀地分布 PN 调制的信号。首先，由乘法器 172a 用短 PN_I 码来调制长 PN 码，以产生信号 LPN_I。长 PN 码也由乘法器 172b 用短 PN_Q 码来调制，以产生信号 LPN_Q。

乘法器 174 和加法器 176 进行信号 X_I 和 X_Q 以及 LPN_I 和 LPN_Q 码的复数乘。用 j 代表复数的虚部，并将上述两个复数项相乘，那么可以得到下面的等式：

$$(X_I + jX_Q) \cdot (LPN_I + jLPQ_Q) = (X_I \cdot LPN_I - X_Q \cdot LPN_Q) + j(X_I \cdot LPN_Q + X_Q \cdot LPN_I) \tag{13}$$

为了得到上述结果，首先由乘法器 174a 用 LPN_I 对信号 X_I 进行调制，以产生乘积项 $X_I \cdot LPN_I$，并由乘法器 174d 用 LPN_Q 调制，以产生乘积项 $X \cdot LPN_Q$。接着，由乘法器 174b 用 LPN_I 对信号进行调制，以产生乘积项 $X_Q \cdot LPN_I$，并由乘法器 174c 用 LPN_Q 调制，以产生乘积项 $X_Q \cdot LPN_Q$。用加法器 176 和 176b 将四个中间项组合，从而合成的信号 $Y_I = X_I \cdot LPN_I - X_Q \cdot LPN_Q$，以及 $Y_Q = X_I \cdot LPN_Q + X_Q \cdot LPN_I$。信号 Y_I 和 Y_Q 被滤波(图 5 中未示出)，并且分别由混频器 178a 和 178b 用同相正弦波 COS(Wct)和正交正弦波 SIN(Wct)调制。来自混频器 178a 的 I 分量和来自混频器 178b 的 Q 分量由加法器 180 组合，并且合成的 QPSK 调制器输出被提供到前端 62。

调制器 74 均匀地将来自 BPSK 和 QPSK 信道编码器 104 和 106 的数据分布在 QPSK 调制器输出的 I 和 Q 分量上。在第一个典型实施例中，假设只出现 BPSK 信道编码器，而没有 QPSK 信道编码器 106。这样，X_I 含有 BPSK 数据，并且 $X_Q=0$。在上述等式(13)中代替这些量，$Y_I = X_I \cdot LPN_I$，并且 $Y_Q=$

$X_I \cdot LPN_Q$。因此，来自 BPSK 信道编码器 104 的 BPSK 数据用不同的短 PN 码扩展，并均匀分布在 I 和 Q 分量之间。

在下一个例子中，假设只存在 QPSK 信道编码器 106，而不存在 BPSK 信道编码器。这样，，X_I 含有 $QPSK_I$ 数据，而 X_Q 含有 $QPSK_Q$ 数据。合成的信号变成 $Y_I = X_I \cdot LPN_I - X_Q \cdot LPN_Q$，以及 $Y_Q = X_I \cdot LPN_Q + X_Q \cdot LPN_I$。因此，$QPSL_I$ 数据用不同的短 PN 码扩展，并均匀分布在 I 和 Q 分量之间。与此类似，$QPSK_Q$ 数据用不同短 PN 码扩展，并均匀地在 I 和 Q 分量之间。等式中 Y_I 前的减号是从复数乘运算得到的。

如上所述，BPSK 或 QPSK 信道编码器的个数是由系统设计选择的。在典型的实施例中，将一个 BPSK 沃尔什调制器 146 分配给每一个 BPSK 信道编码器 104，并将一个 QPSK 沃尔什调制器 148 分配给每一 QPSK 信道编码器 106。每一对 BPSK 信道编码器 104 和 BPSK 沃尔什调制器 146 在本说明书中总称为第二编码信道。与此类似，每一对 QPSK 信道编码器 106 和 QPSK 沃尔什调制器 148 总称为第二编码信道。

在第一种实施例，通过改变重复值 N_I 和 N_Q，可以使 BPSK 和 QPSK 信道上的数据传输速率为可变。包括有导频音使得小区能够用部分相干解调来提高 FER 特性。导频音使得反向链路能够在相同 FER 性能的更低的 $E_{bi}/(N_o + I_o)$ 下工作。同时，当数据传输速率较高时，导频音使用的发射功率的百分比较小。第一个实施例的缺点是 QPSK 调制器输出不符合反向链路上调制信号的 IS－95A 标准。所以，按照第一个实施例产生的调制信号反向是不与符合 IS－95A 标准的 CDMA 系统兼容的。

第二实施例的编码器 72 和调制器 74 的典型方框图如图 6 所示。第二编码信道是通过采用沃尔什码扩展来产生的，从而在第二编码信道之间提供正交性。通过在正被解调的其他第二编码信道上提供相关的信号，以及扩展其他第二编码信道的信号，正交性改进了小区处的信号检测。随后，按照 IS－95A 标准，对沃尔什码扩展信号进行信号映射(map)，以改进信号的检测。最后，由短 PN 码对经的信号进行扩展，以提供正交扩展，从而再次改进了小区处的信号检测。

参见图 6，将来自数据源 70 的数据提供到产生用于正被传送的数据帧的 CRC 位的发生器 140，并插入编码尾位。将经 CRC 编码的数据提供到卷积编码器 142，对经 CRC 编码的数据进行卷积编码。经编码的位被提供到块交

错器 144，对经编码的位进行重新排序，以提供时间分集。经交错的数据被提供到调制器 74。

在调制器 74 内，确定编码数据通过 DEMUX 146 的路由，并且编码数据被提供到一组沃尔什编码调制器 182。沃尔什码调制器 182 用特有的沃尔什码对经编码的数据进行扩展，以提供编码信道之间的正交性。沃尔什码调制的数据被提供到正交调制器(ortho-modulator)184。正交调制器 184 用沃尔什码映射将输入信号映射到另一个信号空间。将输入位序列组合成 6 位的编组。每一 6 位编组选择一个特有的 64 子码沃尔什序列。将来自正交调制器 184a 的变换信号提供到数据　函数发生器 186。当远端站 6 在小于全速率下发射时，数据突发随机函数发生器 186 关闭前端 62 内的发射机，以减小发射功率。

由于沃尔什码 W_0 被定义为全零序列(0,0,…,0)，所以沃尔什码调制器 182a 不起任何作用。所以，包含沃尔什码调制器 182a、正交调制器 184a 和数据突发随机函数发生器 186 的第一沃尔什码信道 W_0 符合用于反向链路的由 IS－95A 标准定义的信号处理。必要时，采用含有沃尔什码调制器 182 和正交调制器 184 的第二沃尔什码信道 W_1－W_N，而不会影响第一沃尔什码信道 W_0 的性能。由加法器 188 将第一沃尔什码信道和第二沃尔什码信道组合，并用乘法器 190 用长 PN 码调制合成的信号。长 PN 码调制的信号进一步分别由乘法器 192a 和 192b 用短 PN_I 码和 PN_Q 码扩展。用混频器 196a 将 PN_I 调制的信号与同相的正弦信号 COS(Wct)混合。经 PN_I 调制的信号延迟半个子码，并通过延迟器(delay)194，由混频器 196b 与正交正弦信号 SIN(Wct)混频。由加法器 198 将来自混频器 196a 的 I 分量和来自混频器 196b 的 Q 分量组合，并将合成的 OQPSK 调制器输出提供到前端 62。该实施例的优点是提供了一种调制信号，该调制信号按照 IS－95A 标准与用于反向链路的调制信号是向后(backwards)兼容的。本说明书中，每一第二沃尔什码信道 W_1－W_N 称为第二编码信道。

IX. CRC 位

按照 IS－95A，将 CRC 位附在每一个数据帧上，使得能够由小区进行帧差错的检测。CRC 位是按照由 IS－95A 规定的 CRC 多项式产生的。具体说来，对于 9.6Kbps 的数据传输速率，所规定的多项式是 $g(x)=x^{12}+x^{11}+x^{10}+x^9+x^8+x^4+x+1$。对于每一个数据帧，附上 12 个 CRC 位。本发明中，根据

所需检测的确定性，CRC 位的数量可以增加或降低。更多的 CRC 位使得能够用更大的确定性来检测帧差错，但所需的开销也更大。相反，较少的 CRC 位降低了帧差错检测的不确定性，但所需的开销较低。

如上所述，根据硬件的结构，可以在可变速率信道或多个第二编码信道上出现高速的传输速率。对于在第二编码信道上出现高速数据传输的结构，可以进一步将数据帧分隔成数据部分，每一数据部分被编码成编码信道帧，并在一个第二编码信道上传送。将下文中有关 CRC 位发生的讨论应用于采用第二编码信道的实施例。当然这一概念也可以扩展到其他的硬件实施例。为简化起见，下文中的讨论假设每一第二编码信道是在最大非预定传输速率下进行发射的。另外，第二编码信道和业务信道也称为编码信道。

在多个编码信道上出现高速数据传输的实施例中，可以由至少两个实施例来产生多个编码信道的 CRC 位。在第一个实施例中，与 IS－95A 标准相似，每一个数据部分上还附有其自身的一组 CRC 位。该实施例需要更多的开销，但可以检测每一个编码信道帧上的帧差错。只有一个错误接收的编码信道帧是再传送的。

在第二个实施例一个帧中分配给远端站 6 的编码信道上传送的数据帧是由一个 CRC 发生器编码的。产生的 CRC 位可以以几种方式中的一种方式来传送。在第一种方式中，如上所述，将数据帧分成几个数据部分。也可以分割 CRC 位，并将这些 CRC 位附于每一个数据部分上。这样，每一个编码信道帧包含一个数据部分和一些 CRC 位。在第二种方式中，CRC 位是在一个编码信道帧上传送的。除了最后的一个编码信道帧以外，所有的编码信道帧中只含有一个数据部分。最后一个编码信道帧含有 CRC 位和一些可能的数据。第二种方式给出了 CRC 位的时间分集，并且改进了小区进行的帧差错检测。

在小区处将编码信道帧重新组合成数据帧。在第二种实施例中，小区只能够判断是否所有的编码信道帧是正确地接收到的，或者判断是否出现了一个或多个编码信道帧。该小区不能够判断哪一个编码信道帧是错误接收的。所以，数据帧错误表示该数据帧的所有编码信道帧需要由小区重新传送。第二个实施例的优点是采用用于数据帧的更小数量的 CRC 位。

举例来说，假设在十二个编码信道上出现高速数据传输。在第一个实施例中，十二个数据部分中的每一个部分上附有其自身的一组十二个 CRC 位。总共需要 144 个 CRC 位用于十二个编码信道帧。这 144 个 CRC 位使得能

够检测每一个单独的编码信道帧上的帧差错。所以，如果某一特定编码信道上的编码信道帧是错误接收的，那么只有错误的帧是要再次传送的。

对于第二个实施例，只用一组 CRC 位来对整个数据帧进行编码。所使用的 CRC 位最好小于第一个实施例中所使用的 CRC 位的总数。在上述例子中，对于十二个编码信道帧来说，所使用的 CRC 位数至少为 12，但小于 144。由于近似有十二倍多的数据位，所以需要更多的 CRC 位来进行更大确定性的帧差错检测。假设 24 个 CRC 位使得能够在具有必须的确定性水平下进行帧差错的检测，那么可以将 24 个 CRC 位分隔成十二个 CRC 块，每一个 CRC 块含有两个 CRC 位。将一个 CRC 块附在十二个数据部分上。另外，可以在一个编码信道帧上传送这 24 个 CRC 位。在小区处，可以重新组合数据部分和 24 个 CRC 位。小区只能够判断是否正确接收了所有十二个编码信道帧。如果指示有帧差错，则小区就不能够判断哪一个编码信道帧的接收有差错。所以，必须由远端站 6 重新传送所有十二个编码信道帧。对于在开销中省下的 120 个 CRC 位，小区仍然能够检测帧差错，但却不具备第一个实施例的精确性了。第二个实施例需要在较少的开销与编码信道帧的冗余再传送之间权衡。

X. 反向链路速率调度的预定

非预定任务的可用反向链路容量预计的精确性可以通过使某一时刻的预计尽可能地接近将要采用的估计的时刻的预计而得到提高。在从预计的时刻到实际使用的时刻的延迟时间内，网络的状态可能已经变化。例如，其他的远端站 6 可能已经启动或停止传送，远端站 6 可能已经加入或从网络中退出，或者信道条件可能已经变化。通过将处理延迟限制在数量较少的帧，可以使预定任务的可用反向链路容量的预计充分精确。在本典型实施例中，处理延迟是 7 个帧或更少。

信道调度程序 12 可以在短时间内作出预告，例如通过保持短调度时间，以提高预告的精确性，并使得信道调度程序 12 能够快速地响应反向链路要求中的变化。本较佳实施例中，预告是每 K 个帧进行一次，每 K 个帧或每一个帧分配最大预定传输速率，并且每 K 个帧将最大预定传输速率的时间表传送到远端站 6。

反向链路速率调度的时序表的典型描述如图 10 所示。在帧 k 处，远端站 6 有大量的数据要传送到小区。远端站 6 在方框 300 处测量数据的队列大小以及对远端站 6 的总发射功率。在帧 k+1 处，远端站 6 在方框 302 处，将

信息发送到小区。在帧 k+2 处，为该小区服务的基站 4 在方框 304 处接收信息，并选择信息通向选择器元件 14 的路由。在帧 k+3 处，整个 CDMA 网络的状态在方框 306 处由选择器元件 14 测量，并传送到信道调度程序 12。本典型实施例中，CDMA 网的状态包括每一小区处由于预定任务的反向链路容量、由每一预定用户传送的数据量、每一远端站 6 的总发射功率、每一远端站 6 的工作成员组，以及远端站 6 的优先顺序。在帧 k+4 处，信道调度程序 12 在方框 308 处分配最大预定传输速率，并将调度信息发送到选择器元件。最大预定传输速率是在帧 k+7 处使用的。

在帧 k+4 中，选择器元件 14 在方框 310 处将在前向链路上在帧 k+5 处传送的数据帧发送到信道元件 40。信道元件 40 在方框 312 处接收来自帧选择器 14 的在帧 k+4 中的数据帧。在帧 k+5 处，信道元件 40 在方框 314，在前向链路上将含有用于帧 k+7 的最大预定传输速率的调度信息发送到远端站 6。在帧 k+6 中，远端站 6 在方框 316 处理前向链路信号、确定最大预定传输速率，并重新构筑硬件，并且必要的话，用于高速传输速率下的数据传输。在帧 k+7 处，在方框 318 处，数据在反向链路上，在最大预定传输速率下或低于该速率下传送到基站 4。

在本典型实施例中，远端站 6 确定它有大量的数据要发送到基站 4 的时间到在高速传输速率下进行数据传输的时间之间的处理延迟是 7 个帧。在帧 k 处，远端站 6 测量队列的大小以及它所具有的总的发射功率。在帧 k+7 处，远端站 6 在高速传输速率下将数据发送到基站 4。对于符合 IS－95A 标准的 CDMA 系统，每一个帧的延迟代表一个 20 毫秒的延迟。在本典型实施例中，7 个帧的处理延迟代表 140 毫秒的延迟。延迟时间足够短，从而反向链路上的其他的通信不会显著劣化。另外，非预定任务所需反向链路容量的初始预告在本发明中不是很严格要求的，这是因为信道调度程序 12 具有连续监视反向链路使用以及动态再分配预定任务的传输速率的能力。

上述典型实施例的描述代表本发明的一种实施结构。也可以采用从上述得到的反向链路速率调度程序的时序的其他变化形式，这些变化形式也是本发明的范围之内。例如，通过使硬件配置为最佳以减小处理延迟，可以将用方框 304、306、308、310 和 312 所代表的处理延迟缩短为一个或两个帧，而不是图 10 中所示的三个帧。

在上述几个实施例中的一个实施例中，可以将含有最大预定传输速率

的调度信息传送到远端站 6。在第一种实施例中，用于前向链路的编码信道帧中的某些位可以反转，用于调度信息。在第二种实施例中，调度信息是用分开的信令消息来发送的。只要有新的数据传输速率分配，信令消息可以被传送到远端站 6。也可以采用上述实施例的变化形式或组合来发送调度信息的其他实施例，这些实施例也落在本发明的范围内。

反向链路速率调度和高速数据传输的典型图见图 11 所示。正如上面所讨论的那样，在与小区进行的通信期间，远端站 6 被分配有一个最大非预定传输速率(速率 1)。如图 11 所示，空闲时，远端站 6 在速率 1/8 下发送，而在进行数据传输时，在速率 1 下发送。要传送到小区的数据存储量用实线代表，并按照编码信道帧的数量给出。编码信道帧的数量等于最大非预定传输速率乘以发送数据所必须的帧的数量。例如，20 个编码信道帧可以在 20 个帧上由速率 1 传送，或者在 5 个帧上由速率 4 传送。下面的讨论涉及先前所描述的实施例，该实施例中，反向链路速率调度是每 K 个帧进行一次，并且每一帧可以重新分配传输速率。同时，远端站 6 可以单方面地减小传输速率。下面的例子也适应于每一帧进行一次反向链路速率调度的实施例。

在图 11 所示的例子中，远端站 6 被分配有一个最大非预定传输速率(速率 1)，但远端站 6 没有在帧 1 和 2 内传送到小区的数据。所以，远端站 6 在反向链路上在速率 1/8 下进行发送。在帧 2 中，远端站 6 接收两个编码信道帧用以传送到小区。远端站 6 在速率 1 下，在帧 3 和 4 中，传送一个编码信道帧，从而在帧 3 结束时使存储量为零。注意，远端站 6 可以在反向链路上在直到速率 1 的速率下发送数据，而无需调度。在帧 2 中接收的数据在帧 3 中立即发送出去。在速率 1 下或低于速率 1 下进行的立即传输使得从远端站 6 到小区的信令能够快速地通过。例如，TCP 确认要求近似为 40 个字节在标题压缩的情况下被装入一个数据帧内。TCP 确认可以在一个帧内，立即在反向链路上传送出去。

在帧 5、6 和 7 中，远端站 6 在空闲以及等待数据时，在速率 1/8 下发送。在帧 7 中，远端站 6 接收大量传送到小区的数据。在帧 8 中，远端站 6 向小区发送队列大小以及远端站已有的总发射功率。在帧 10 中，信道调度程序 12 从选择器元件 14 接收信息，并收集有关网络状态的其他信息(例如网络中每一小区可用的反向链路容量)。在帧 11 中，信道调度程序 12 分配最大预定传输速率，并将时间表传送到小区。本例中，信道调度程序 12 分

配一个四倍于最大非预定传输速率的最大预定传输速率(速率 4)。在帧 12 内，小区在前向链路上将调度信息发送到远端站 6。在帧 8 到 13 中，远端站 6 继续在速率 1 下发送数据，并使存储量为 26 个编码信道帧。帧 13 中，远端站 6 接收调度信息，并构筑其硬件，使其在高速传输速率下发送数据。高速数据传输是发生在帧 14 到 19 中最大预定传输速率(速率 4)下的。

帧 19 中，远端站 6 知道队列几乎为空，并且需要传输速率 2 来发送帧 20 内的其余的数据。帧 20 中，远端站 6 向小区发送速率减小的消息，表示想要在更低的传输速率下进行发送。同时，在帧 20 中，远端站 6 在更低的传输速率下发送两个其余的编码信道帧。

在帧 21 中得知队列为空，远端站 6 请求终断在最大预定传输速率(速率 4)下的传送。在帧 21 中，在传送了所有的数据以后，远端站 6 在空闲和等待更多的数据时，在速率 1/8 下进行发送。

上面例子给出，在远端站 6 处具有数据的时刻(图 11 中的帧 7 中)与在高速传输速率下进行数据传输的时刻之间(图 11 中的帧 14 中)，有 7 个帧的处理延迟。该例子还描绘了可以由远端站 6 在每一个帧中减小传输速率，从而在每一个帧中使反向链路得到完全的利用。

XI. 优先顺序分配

为了使反向链路得到最好的利用，按照远端站 6 的优先顺序向远端站 6 分配用于预定任务的最大预定传输速率。反向链路容量首先分配到具有最高优先顺序的远端站 6，最后分配到具有最低优先顺序的远端站 6。有几个因素可以用来决定远端站 6 的优先顺序。下面的讨论详细给出了一个在分配优先顺序时可以考虑的某些因素的表。可以考虑的还有其他一些因素，这些因素同样也落在本发明的范围内。

决定远端站 6 中的优先顺序的一个重要因素是远端站 6 所需的 $E_b/(N_o+I_o)$。因需要必须的性能水平而要求更高 $E_b/(N_o+I_o)$ 的远端站 6 与需要更低的 $E_b/(N_o+I_o)$ 的远端站 6 相比消耗更大的容量。事实上，对于一个给定的反向链路容量，可以由远端站 6 传送的码元速率反比于所要求的 $E_b/(N_o+I_o)$。举例来说，如果第二远端站 6 所需的 $E_b/(N_o+I_o)$ 近似大于第一远端站 6 所需 $E_b/(N_o+I_o)$ 6dB，那么由第一远端站 6 在 38.4 Kbps 下支持数据传输的反向链路容量仅支持由第二远端站 6(1/4 码元速率)在 9.6 Kbps 下的数据传输。所以，由于消耗的容量较低，所以最好使需要较低 $E_b/(N_o+I_o)$ 的远

端站 6 首先进行发送。

远端站 6 可以处于与多个小区进行软切换的状态下。由于多个小区同时支持远端站 6，所以处于软切换状态的远端站 6 消耗更大的容量。所以，反向链路上更高的通过量(throughput)是通过向处在软切换状态下的远端站 6 分配低的优先顺序来得到的。同时，处在软切换状态下的远端站 6 通常靠近小区的边缘，并且需要更大的发射功率，用于小区中每一位相同的能量。

信道调度程序 12 还可以考虑远端站 6 所需用以发送到小区的每位的发射能量。远端站 6 的发射功率通常有限，并且反向链路速率调度可以试图保留电池功率，以延长远端站 6 的工作寿命。

最大预定传输速率的最佳分配还取决于要由远端站 6 传送的数据量。要传送的数据存储在远端站 6 中的队列中。所以，队列的大小表示要传送的数据量。在每一调度时间的开始处，所有预定任务的队列大小被发送到信道调度程序 12。如果预定任务的队列大小较小，则信道调度程序 12 从速率调度程序中去掉该任务。数量较少的数据的传送可以在最大非预定传输速率下或在低于最大非预定传输速率的速率下，在反向链路上，在令人满意的时间内完成。信道调度程序 12 只在必要时分配高速传输速率用于大量的数据传输。因此，分配给每一远端站 6 的最大预定传输速率可以近似地正比于要传送的数据的大量大小。

要传送的数据类型是在各远端站 6 中分配优先顺序时要考虑的另一个重要的因素。某些数据类型对时间很敏感，需要很快注意。其他的数据类型在传输时允许有更长的延长时间。很明显，将较高的优先顺序分配给时间要求较严的数据。

举例来说，小区不可避免会错误地接收到某些传送的数据。该小区能够用编码信道帧上所附的 CRC 位来判断帧差错。在判断接收到的编码信道帧有差错时，给该编码信道帧打上差错指示位，并且小区将该帧差错通知远端站 6。信道调度程序 12 于是对错误接收的编码信道帧的重新传输作出预定，或者远端站 6 进行重新发送，并通知小区。在小区处，可以根据错误接收的编码信道帧进行其他的信号处理。所以，信道调度程序 12 或远端站 6 可以把要再传送的数据放在比第一次传送的数据更高的优先顺序上。

相反，小区给出的重复帧差错指示可以表示该反向链路受到损害(impaired)。所以，分配用于错误接收的编码信道帧重复再传送的反向链路

容量是不浪费的。这时，远端站 6 可以暂时被置于保持状态，或被分配一个较低的传输速率。在保持状态下，可以中断高速传输速率下的数据传输，直到反向链路条件得到改进。远端站仍然可以在最大非预定速率下或在低于该速率的速率下传送数据，并且小区可以继续监视反向链路的性能。在接收到反向链路提得到改进的指示以后，信道调度程序 12 从保持状态中去掉远端站 6，并指挥远端站 6 恢复向小区进行高速数据传输。

在各远端站 6 中分配优先顺序时，会要求按照正向远端站 6 提供的数据服务的类型来区分远端站 6。例如，可以为不同的数据传输服务建立起一个价格结构。向那些收取高价的服务提供更高的优先顺序。通过价格结构，每一远端站 6 上的用户可以独立地确定优先顺序，因此，也能够独立地确定用户可以享用的服务。

远端站 6 的优先顺序还可以取决于远端站 6 所已经经历的延迟量。首先将已有的反向链路容量分配给具有最高优先顺序的远端站 6。因此，具有低优先顺序的远端站 6 通常将经历较长的传输延迟。当低优先顺序的远端站 6 所经历的延迟量增加时，远端站 6 的优先顺序将升级。这就防止了数据从队列状态中的余者由低优先顺序的远端站 6 无限制地传送出去。没有优先顺序的升级，低优先顺序的远端站 6 会经受不可容忍的延迟量。优先顺序升级会以这样一种方式递增，即，实现预定和非预定任务高质量的通信，同时保持系统的目标。

根据正使之最佳化的一组系统目标，对上述因素给出不同的加权。举例来说，为了使反向链路上的通过量为最佳，使远端站 6 所需的 $E_b/(N_o+I_o)$ 具有更大的权，并且使远端站 6 处在软切换状态。这种加权方式无需考虑数据的类型以及远端站 6 的优先顺序，从而无需考虑公平的系统目标。根据 FER、所需 $E_b/(N_o+I_o)$ 的预告以及软切换分配优先顺序的典型的等式可以表述为：

$$C_i = \frac{1}{(1-P_e)} \bullet \sum_{j=1}^{L} \gamma_{i,j} \tag{14}$$

这里，C_i 是第 i 个远端站 6 的优先顺序，L 是支持软切换状态下远端站 6 的小区数，P_e 是 FER，而 γ_i 是所需 $E_b/(N_o+I_o)$ 的预告的远端站 6 的设置点。本例中，使 C_i 的较低值等于更高的优先顺序。也可以考虑采用其他具

有不同加权因子的等式，并且这些等式也在本发明的范围内。

另一种情况是，可以保持一种价格结构，使得每一远端站 6 上的用户能够独立地确定远端站 6 的优先顺序。对容量付 较高的价钱的想法表示更高的重要等级。这时，试图使受益为最大并使满足客户要求的系统使得高级的远端站 6 能够首先进行发送，尽管该传输要求更高的容量。也可以采用上述因子加上未讨论过的其他因子来产生其他的加权分案，以实现任何一组系统目标，这也落在本发明的范围内。

前文中对较佳实施例的描述使得本领域中的普通技术人员能够制造和使用本发明。很明显，对本领域中的技术人员来说，还可以对这些实施例作各种修改，并且可以将这些基本原理应用于其他的实施例，而无需发明专门人员的帮助。所以，本发明并非仅限于这些实施例，应当从最宽的范围来理解所揭示的本发明的原理和新特征。

99.12.06

说 明 书 附 图

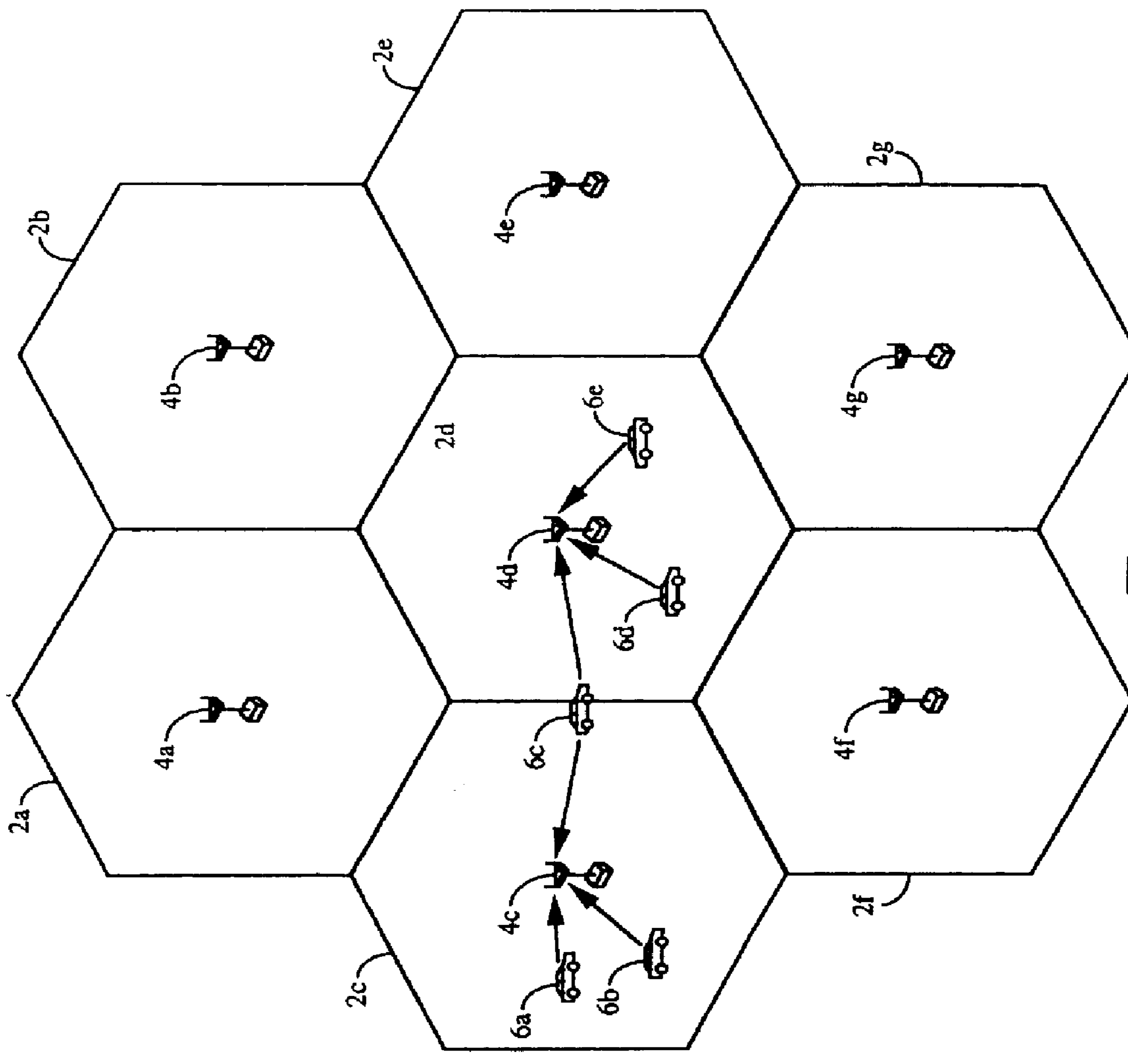
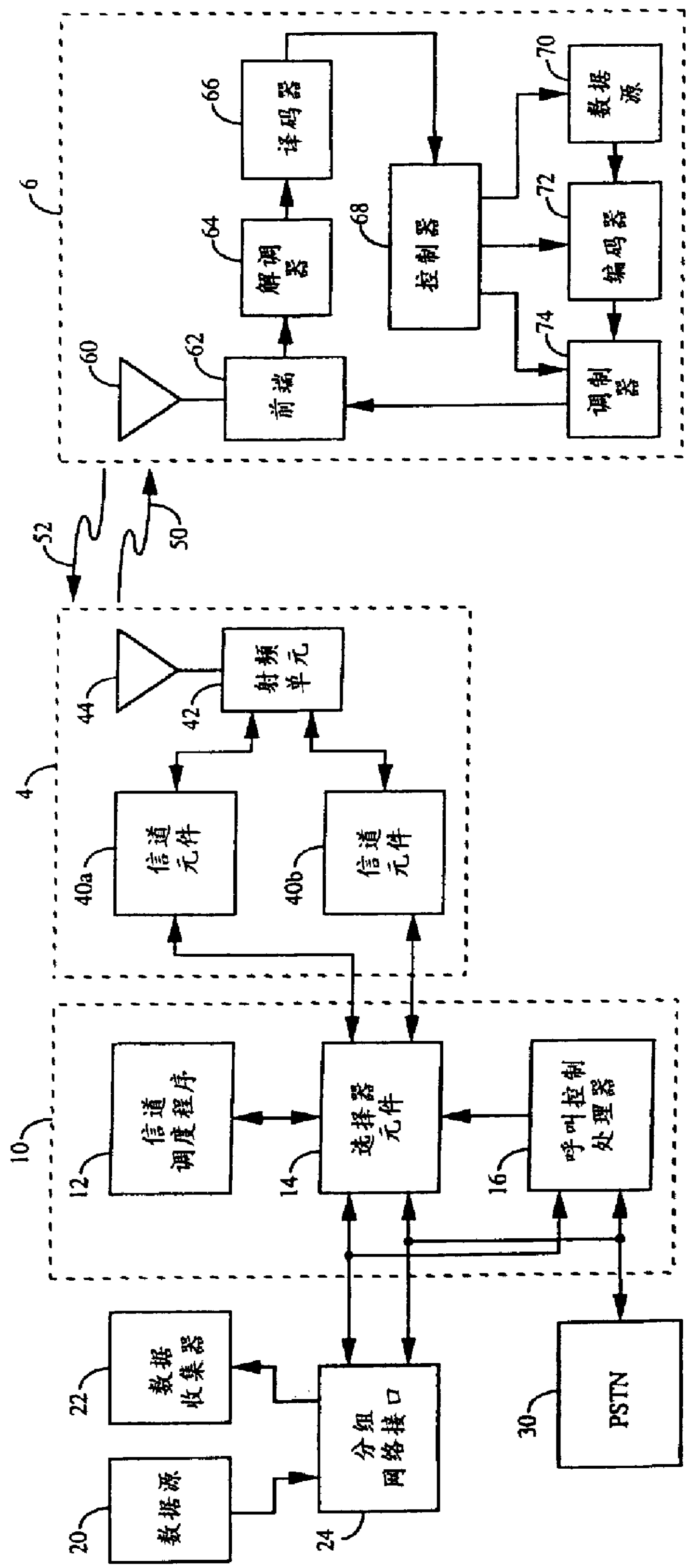


图 1

99.12.06



6
60
62
前端
64
解调器
66
译码器
68
控制器
70
数据源
72
编码器
74
调制器
52
50
4
44
42
射频单元
40a
信道元件
40b
信道元件
10
12
信道调度程序
14
选择器元件
16
呼叫控制处理器
20
数据源
22
数据收集器
24
分组网络接口
30
PSTN

图 2

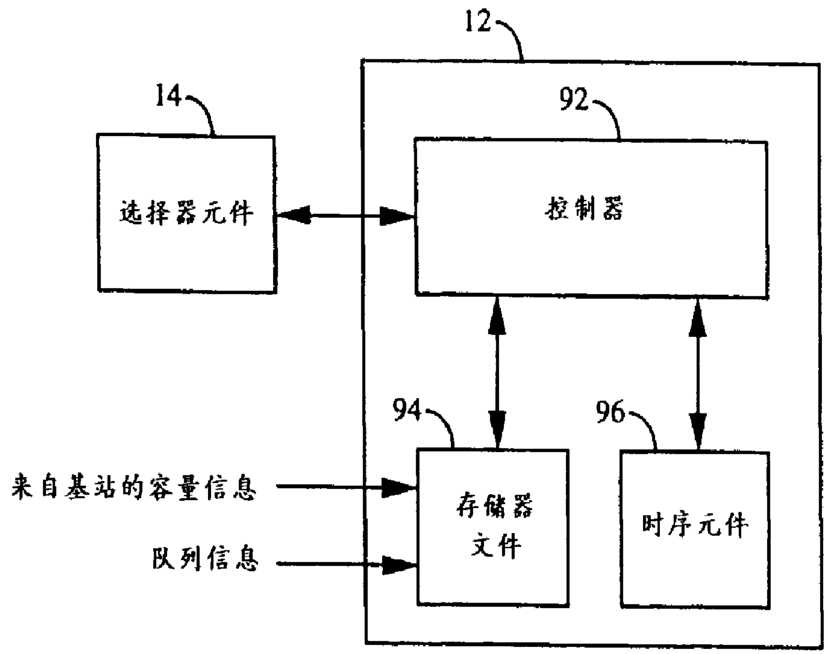


图 3

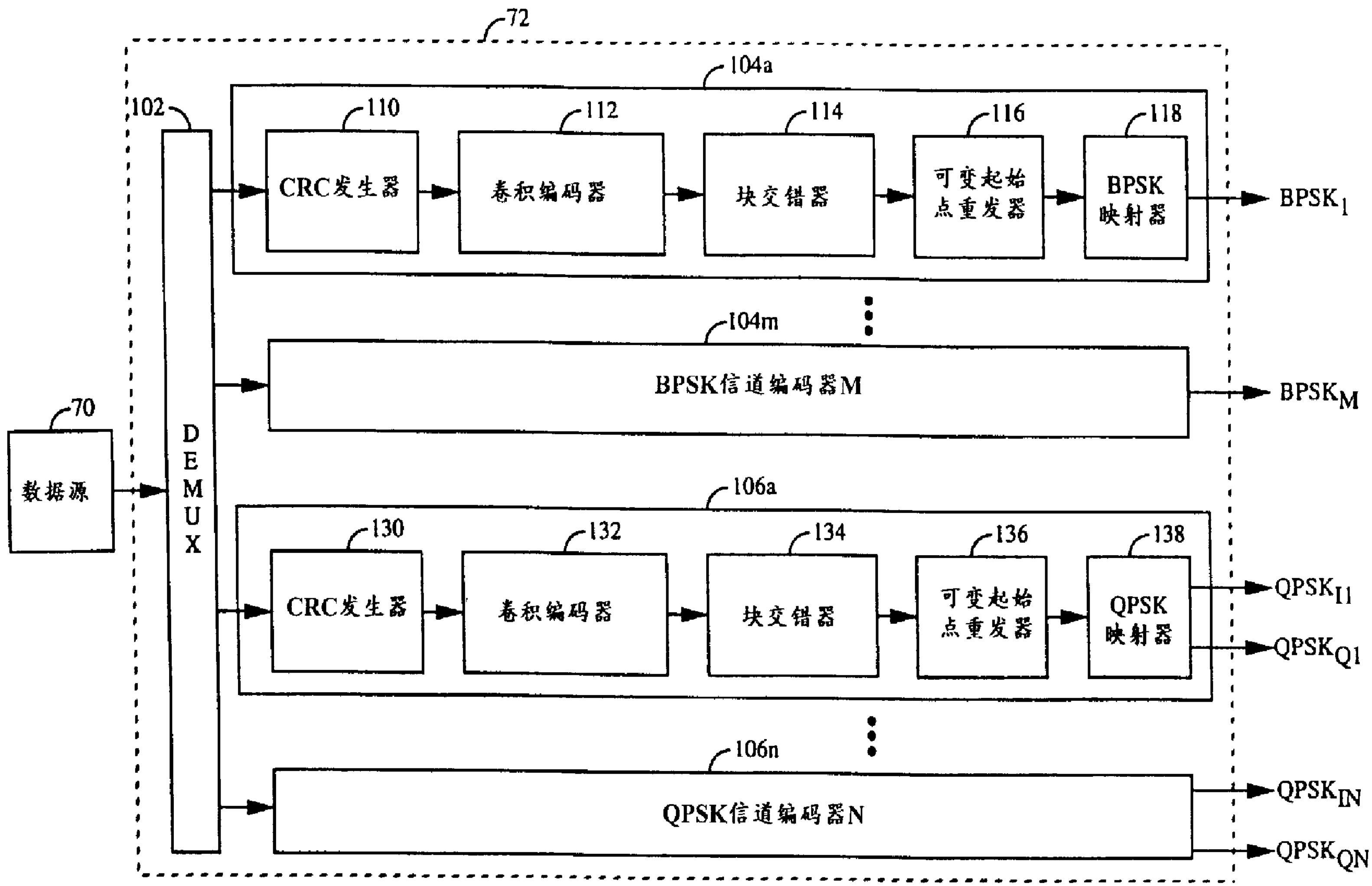

72
102
104a
110
CRC发生器
112
卷积编码器
114
块交错器
116
可变起始点重发器
118
BPSK映射器
BPSK1
104m
BPSK信道编码器M
BPSKM
70
数据源
DEMUX
106a
130
CRC发生器
132
卷积编码器
134
块交错器
136
可变起始点重发器
138
QPSK映射器
QPSKI1
QPSKQ1
106n
QPSK信道编码器N
QPSKIN
QPSKQN

图 4

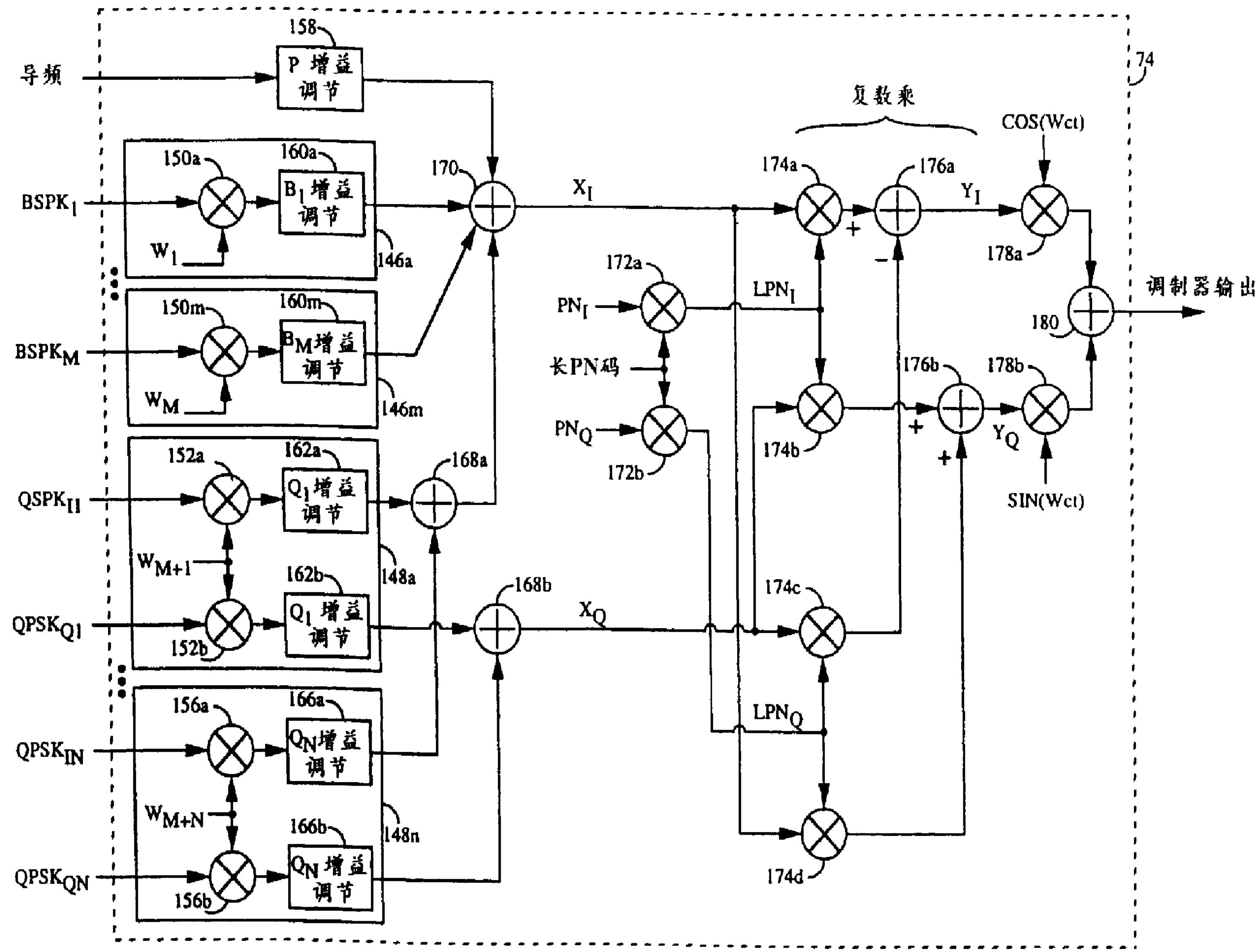
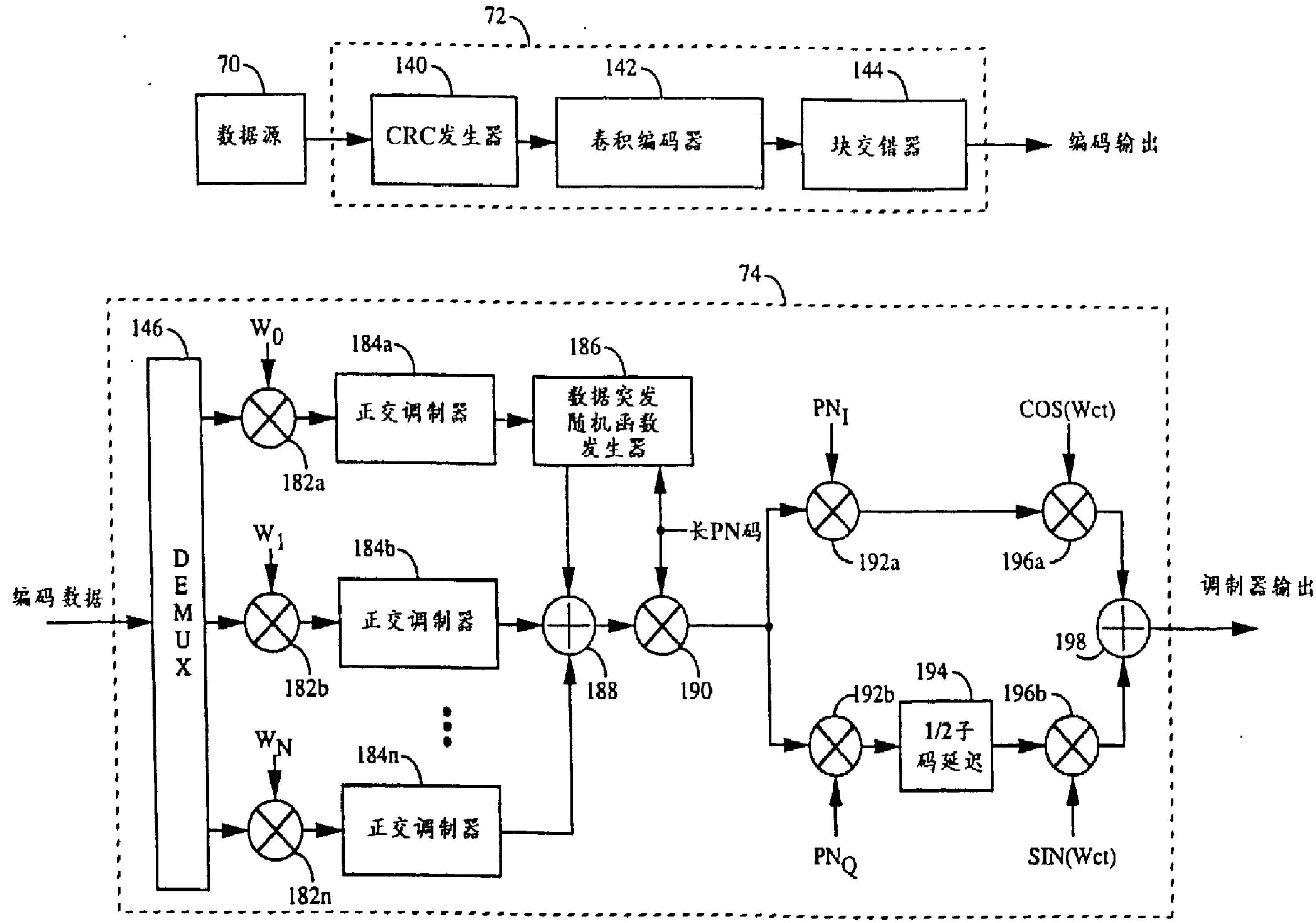

导频
BSPK$_1$
BSPK$_M$
QSPK$_{I1}$
QPSK$_{Q1}$
QPSK$_{IN}$
QPSK$_{QN}$
158
P 增益调节
150a
160a
B$_1$增益调节
W$_1$
146a
150m
160m
B$_M$增益调节
W$_M$
146m
152a
162a
Q$_1$增益调节
W$_{M+1}$
162b
Q$_1$增益调节
152b
148a
156a
166a
Q$_N$增益调节
W$_{M+N}$
166b
Q$_N$增益调节
156b
148n
170
168a
168b
X$_I$
X$_Q$
172a
PN$_I$
长PN码
PN$_Q$
172b
LPN$_I$
LPN$_Q$
复数乘
174a
174b
174c
174d
176a
176b
Y$_I$
Y$_Q$
COS(Wct)
SIN(Wct)
178a
178b
180
调制器输出
74

图 5



70
数据源
72
140
CRC发生器
142
卷积编码器
144
块交错器
编码输出
74
编码数据
146
DEMUX
W_0
182a
184a
正交调制器
W_1
182b
184b
正交调制器
W_N
182n
184n
正交调制器
186
数据突发随机函数发生器
188
190
长PN码
PN_I
192a
PN_Q
192b
194
1/2子码延迟
COS(Wct)
196a
SIN(Wct)
196b
198
调制器输出

图 6

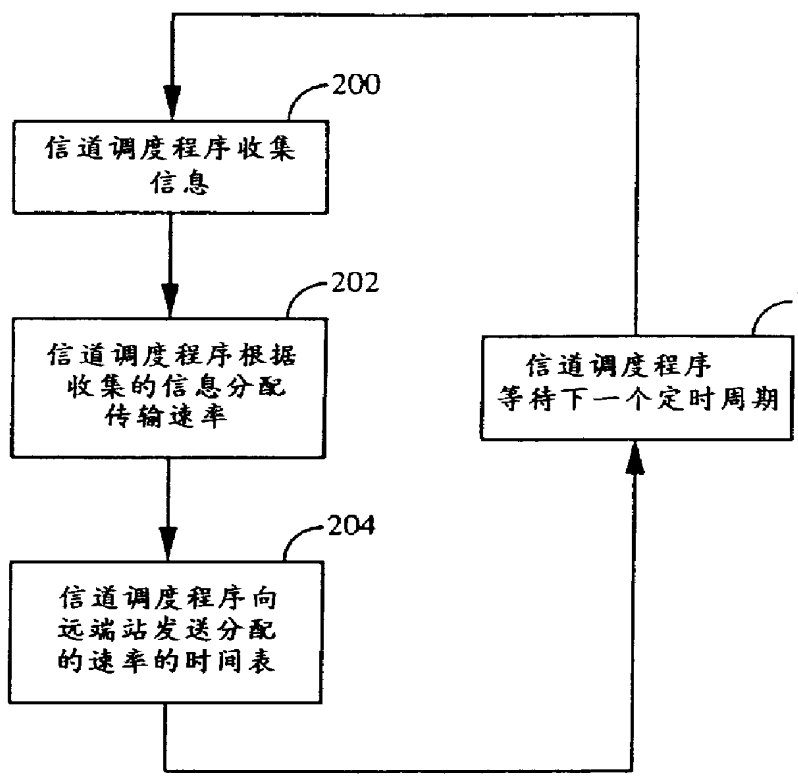
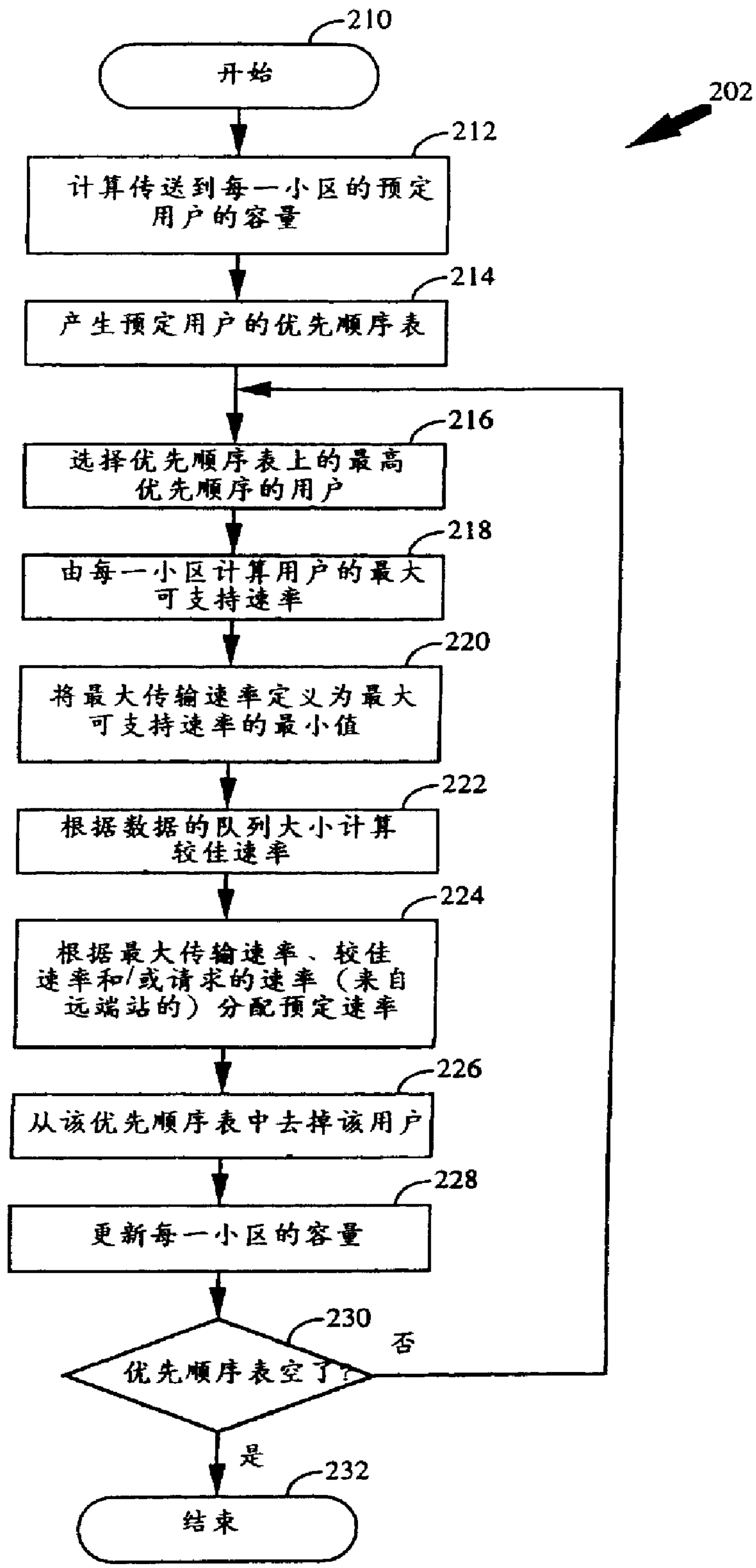

200
信道调度程序收集信息
202
信道调度程序根据收集的信息分配传输速率
204
信道调度程序向远端站发送分配的速率的时间表
206
信道调度程序等待下一个定时周期

图 7



202
210
开始
212
计算传送到每一小区的预定用户的容量
214
产生预定用户的优先顺序表
216
选择优先顺序表上的最高优先顺序的用户
218
由每一小区计算用户的最大可支持速率
220
将最大传输速率定义为最大可支持速率的最小值
222
根据数据的队列大小计算较佳速率
224
根据最大传输速率、较佳速率和/或请求的速率（来自远端站的）分配预定速率
226
从该优先顺序表中去掉该用户
228
更新每一小区的容量
230
优先顺序表空了?
否
是
232
结束

图 8

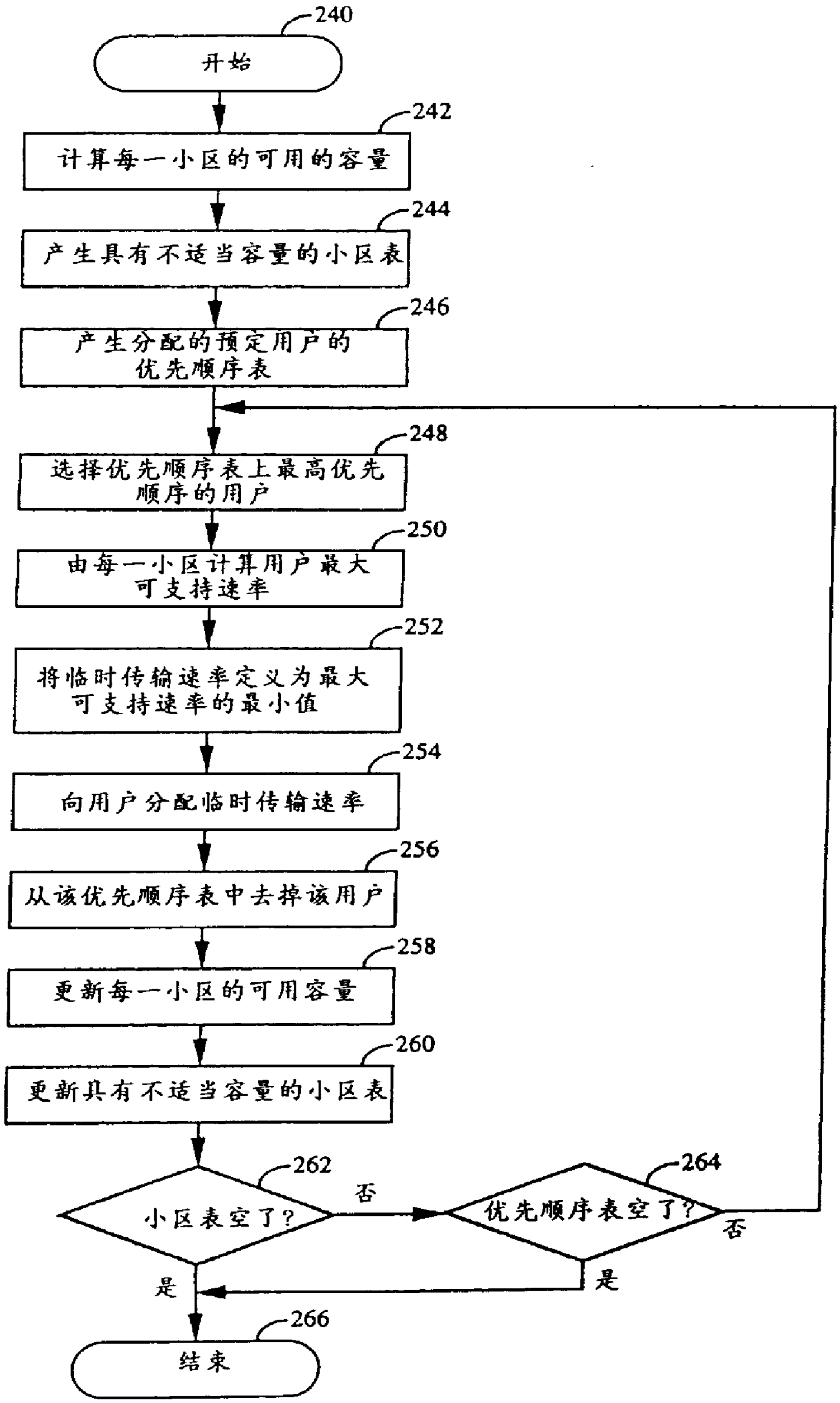

240
开始
242
计算每一小区的可用的容量
244
产生具有不适当容量的小区表
246
产生分配的预定用户的优先顺序表
248
选择优先顺序表上最高优先顺序的用户
250
由每一小区计算用户最大可支持速率
252
将临时传输速率定义为最大可支持速率的最小值
254
向用户分配临时传输速率
256
从该优先顺序表中去掉该用户
258
更新每一小区的可用容量
260
更新具有不适当容量的小区表
262
小区表空了?
否
264
优先顺序表空了?
否
是
是
266
结束

图 9

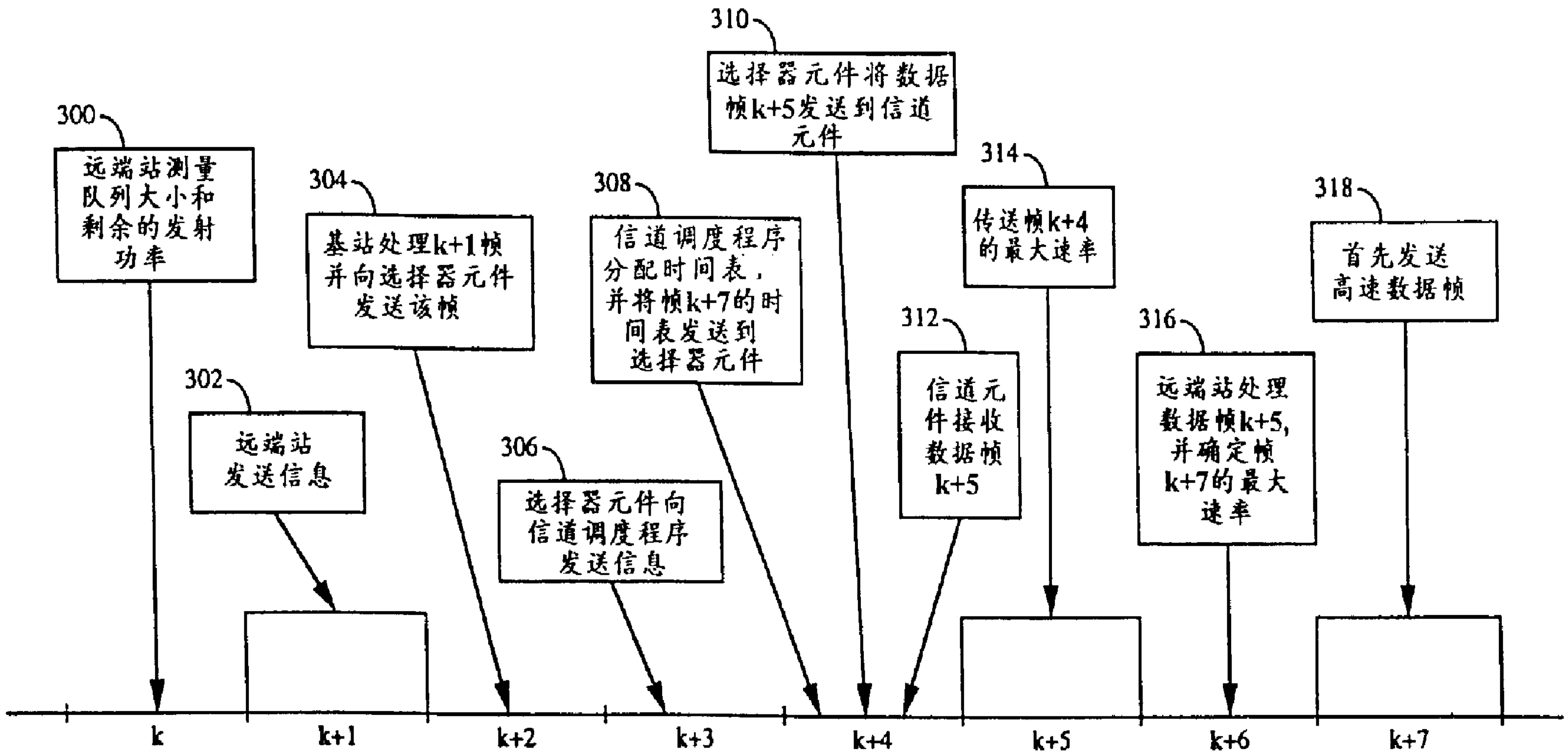
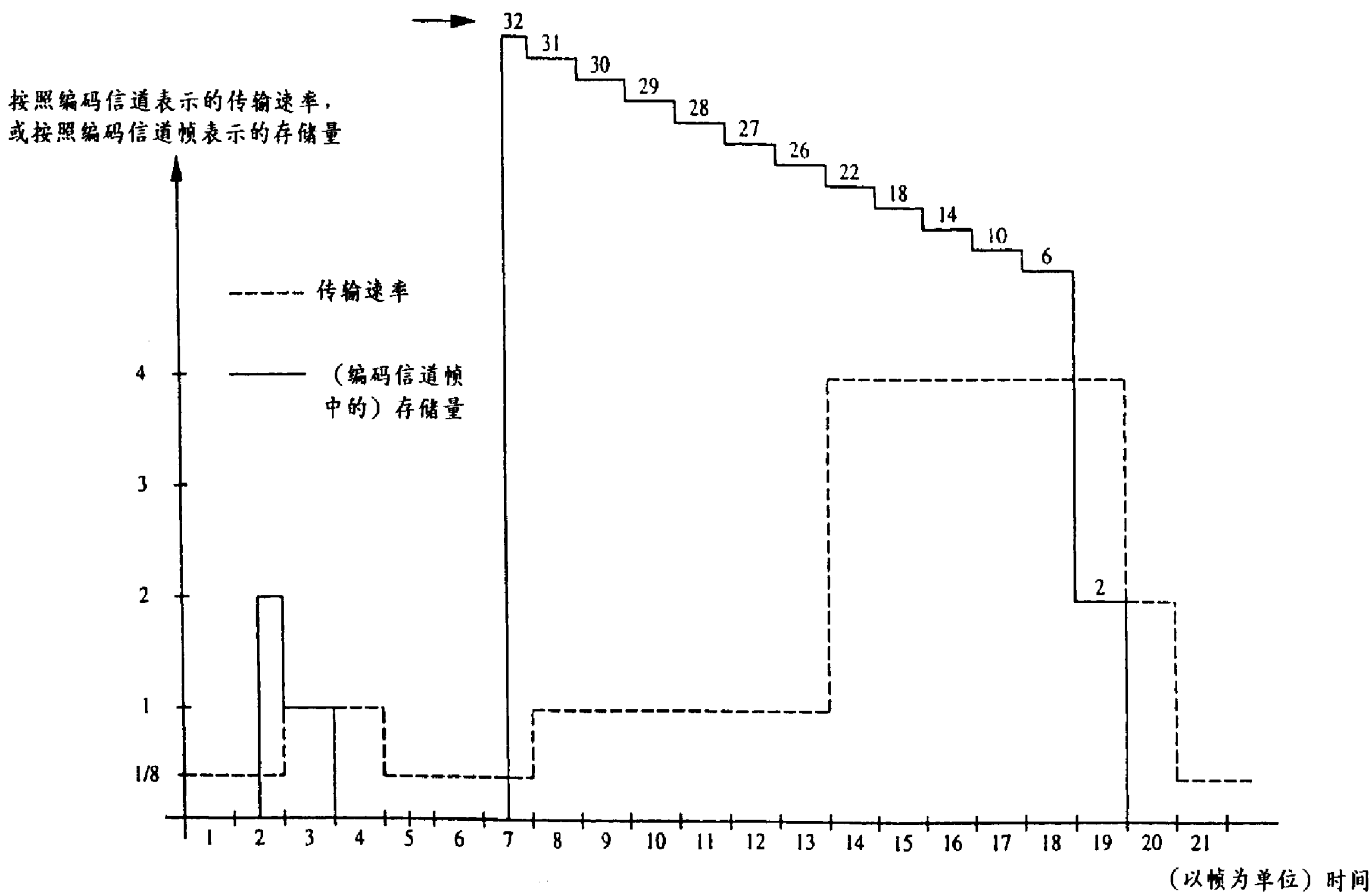

300
远端站测量队列大小和剩余的发射功率
302
远端站发送信息
304
基站处理k+1帧并向选择器元件发送该帧
306
选择器元件向信道调度程序发送信息
308
信道调度程序分配时间表，并将帧k+7的时间表发送到选择器元件
310
选择器元件将数据帧k+5发送到信道元件
312
信道元件接收数据帧k+5
314
传送帧k+4的最大速率
316
远端站处理数据帧k+5，并确定帧k+7的最大速率
318
首先发送高速数据帧
k
k+1
k+2
k+3
k+4
k+5
k+6
k+7

图 10



按照编码信道表示的传输速率，
或按照编码信道帧表示的存储量
传输速率
（编码信道帧中的）存储量
4
3
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图 11

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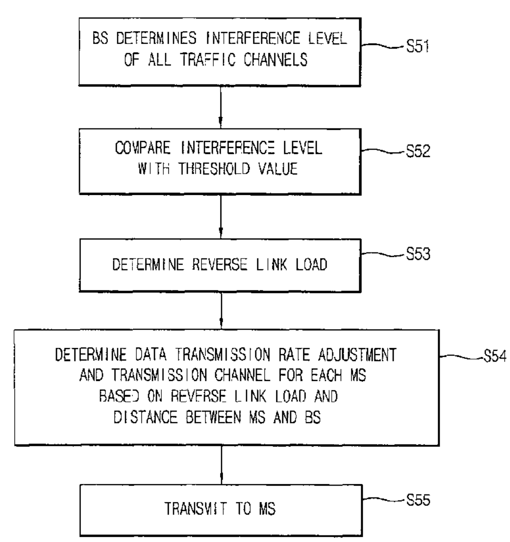
(54) **Controlling data transmission rate on the reserve link for each mobile station in a dedicated manner**

(57) The data transmission rate on the reverse link in a mobile communications system is controlled by determining an interference level at a base station due to signals from all mobile stations served by the base station, and determining a transmission energy level required for each mobile station. The interference level is compared with the transmission energy level to obtain a comparison result for each mobile station, and each mobile adjusts its data transmission rate based upon the comparison result, which is sent via a common channel on a forward link to each mobile station in a dedicated manner. Thereafter, packet data is transmitted on the reverse link in accordance with the adjusting so that data throughput can be maximized.

FIG. 5



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Description

FIELD OF THE INVENTION

[0001] The present invention generally relates to mobile (or wireless) communications, and in particular, to controlling data transmission (transfer) rates between a base station and mobile stations served by the base station so that data throughput is advantageously increased.

BACKGROUND OF THE INVENTION

[0002] Mobile communications involve, among various processing procedures, signal transmissions and handling of data traffic between an access network (AN) and an access terminal (AT). An access network (AN) comprises many elements, one of which being a base station, as known by those skilled in the art. An access terminal (AT) can be in many forms, including a mobile station (e.g., a mobile phone), a mobile terminal (e.g., a laptop computer), and other devices (e.g., a personal digital assistant: PDA) having the combined functionality of both a mobile station and a mobile terminal, or having other terminal capabilities. Hereinafter, an access terminal (AT) will be referred to as a "mobile" for the sake of brevity.

[0003] In a conventional mobile communications system, a plurality of mobiles (e.g., cellular phones, portable computers, etc.) are served by a network of base stations, which serve to allow the mobile stations to communicate with other components in the communications system. Various types of mobile communications systems are known, including Code Division Multiple Access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), and various enhancements and improvements thereto which are generally referred to as next generation mobile communications systems.

[0004] CDMA is most widely accepted and continues to develop and evolve. In particular, CDMA technology evolution (such as the so-called "cdma2000" technology or other next generation CDMA systems) will provide integrated voice with simultaneous high-speed packet data, video and video conferencing capabilities. Currently, the third generation (3G) evolution of cdma2000 1X wireless communications is being reviewed or partially adopted by certain standards bodies, such as 3GPP and 3GPP2 (The Third Generation Partnership Project 2).

[0005] For example, a baseline framework for cdma2000 1xEV-DV (1xEVolution - Data and Voice) was recently reached by the 3GPP2. The 1xEV-DV standard will be backward compatible with existing CDMA IS-95A/B and CDMA2000 1x systems, allowing various operators seamless evolution for their CDMA systems. Other types of systems that are evolving from CDMA include High Data Rate (HDR) technologies, 1xEvolution - Data Only (1xEV-DO) technologies, and the like, which will be explained in more detail hereinafter.

[0006] The present disclosure focuses on data transmission techniques between base stations and mobiles. Thus, a detailed description of additional components, elements and processing procedures (not specifically mentioned herein) have been omitted so that the features of the present invention are not obscured. One skilled in the art would have understood that various other components and techniques associated with base stations and mobiles already known in the art but not described in detail herein, are also part of the present invention. For example, specific details of the protocol architecture having an air interface with a layered structure, physical layer channels, protocol negotiation and processing, and the like have been omitted.

[0007] In a communications system, a set of "channels" allow signals to be transmitted between the access network (e.g., a base station) and the access terminal (e.g., a mobile) within a given frequency assignment. Channels consist of "forward channels" and "reverse channels."

[0008] Signal transmissions (data transmissions or transfers) from the base station to a mobile via a downlink (i.e., forward channels) are commonly referred to as the "forward link," while signal transmissions from the mobile to the base station via an uplink (i.e., reverse channels) are commonly referred to as the "reverse link."

[0009] So-called "physical layers" provide the channel structure, frequency, power output, modulation, and encoding specifications for the forward and reverse links. The "forward channels" consist of those physical layer channels transmitted from the access network to the access terminal, and "reverse channels" consist of those physical layer channels transmitted from the access terminal to the access network.

[0010] Of the many portions of the forward and reverse channels, the "forward MAC channel" is the portion of the forward channel dedicated to medium access control (MAC) activities. The forward MAC channel consists of the reverse power control (RPC) channel, the reverse activity (RA) channel, and other channels. Here, the forward MAC reverse activity (RA) channel indicates the activity level (e.g., the load) on the reverse channel.

[0011] In the so-called Interim Standard 95A (IS-95A) systems, the forward link and the reverse link are allocated separate frequencies and are independent of one another. For code division multiple access (CDMA) technology is the basis for Interim Standard 95 (IS-95) and can operate in both the 800-MHz and 1900-MHz frequency bands. In CDMA systems, communications between users are conducted through one or more cells/sectors, which are serviced

by base stations. A user of a first mobile communicates with another user on a second mobile by transmitting voice and/or data on the reverse link to a cell/sector. The cell/sector receives the data for routing to another cell/sector or a public switched telephone network (PSTN). If the second user is on a remote station, the data is transmitted on the forward link of the same cell/sector, or a second cell/sector, to the second remote station. Otherwise, the data is routed through the PSTN to the second user on the standard phone system.

[0012] A mobile communications system can employ connectionless network services in which the network routes each data packet individually, based on the destination address carried in the packet and knowledge of current network topology. The packetized nature of the data transmissions from a mobile allows many users to share a common channel, accessing the channel only when they have data to send and otherwise leaving it available to other users. The multiple access nature of the mobile communications system makes it possible to provide substantial coverage to many users simultaneously with the installation of only one base station in a given sector.

[0013] The transfer of digital data packets differs from the transfer of digital voice information. Full duplex (simultaneous two-way) voice communication patterns imply that the data, transferred between the base station and a particular mobile station, are real-time and substantially equal in bandwidth. It has been noted that a total delay of 200 msec (about 2 Kbits of digital data for most speech vocoders) represents intolerable latency within a voice channel. On the other hand, transfer of digital data packets is typically asymmetrical, with many more packets being sent from the base station to a particular mobile via a downlink (the forward link), than from the mobile to the base station via an uplink (the reverse link).

[0014] In high speed data packet transfers, users appear to be tolerant of data transfer latencies or delays, with latencies of up to 10 seconds being encountered in current wireless data systems. While such delays appear to be tolerated by the user, the delays, attributable to relatively low effective data transfer rates, are undesirable. One proposed solution, known as "CDMA / HDR" (Code Division Multiple Access / High Data Rate), uses various techniques to measure channel data transfer rate, to carry out channel control, and to mitigate and suppress channel interference.

[0015] Conventional CDMA systems must handle both voice and data. To handle voice signals, the delay between the time that information is sent and the time that the information is received must be kept relatively short. However, certain communications systems used mostly for handling data packets can tolerate relatively longer delays or latencies between the time that information is sent and the time that the information is received. Such data handling communications systems can be referred to as High Data Rate (HDR) systems. The following description will focus on HDR systems and techniques, but those skilled in the art would understand that various other mobile communications systems and techniques for handling high data rates, such as 1xEV-DO, 1xEV-DV, and the like, fall within the scope of the present disclosure.

[0016] In general, a High Data Rate (HDR) system is an Internet protocol (IP) based system that is optimized for transmitting data packets having bursty characteristics and not sensitive to latencies or delays. In HDR systems, a base station is dedicated to communicating with only one mobile station at any one time. An HDR system employs particular techniques allowing for high-speed data transfers. Also, HDR systems are exclusively used for high-speed data transfers employing the same 1.25MHz of spectrum used in current IS-95 systems.

[0017] The forward link in an HDR system is characterized in that the users are not distinguished in terms of orthogonal spreading codes, but distinguished in terms of time slots, whereby one time slot can be 1.67ms (milliseconds). Also, on the forward link of an HDR system, the mobile (access terminal AT) can receive data services from about at least 38.4 Kbps to about at most 2.4576 Mbps. The reverse link of an HDR system is similar to the reverse link of an IS-95 system, and employs a pilot signal to improve performance. Also, traditional IS-95 power control methods are used for providing data services from about 9.6 Kbps to about 153.6 Kbps.

[0018] In the HDR system, a base station (a part of the access network AN) can always transmit signals at its maximum transmission power, as virtually no power control is required because only one user occupies a single channel at a particular time resulting in practically no interference from other users. Also, in contrast to an IS-95 system requiring an equal data transfer rate for all users, an HDR system need not deliver packet data to all users at equal data transfer rates. Accordingly, users receiving high strength signals can receive services employing high data rates, while users receiving low strength signals can be accorded with more time slots so that their unequal (i.e., lower) data rate is compensated.

[0019] In conventional IS-95 systems, because various signals (including pilot signals) are simultaneously transmitted to all users, interference due to pilot signals and undesirably high power consumption are problematic. However, in HDR systems, pilot signals can be transmitted at maximum power because the so-called "burst" pilot signals are employed. Thus, signal strength can be measured more accurately, error rates can be reduced, and interference between pilot signals is minimized. Also, as the HDR system is a synchronous system, pilot signals in adjacent cells are simultaneously transmitted, and interference from pilot signals in adjacent cells can also be minimized.

[0020] Figure 1 shows a portion of a conventional reverse channel structure for sending transmission data rate increase information from a base station to a mobile. A base station (not shown) approximates (or measures) a load on the reverse link, and prepares to send to a mobile (not shown) various messages indicating whether the reverse link

load is large or small. A bit repetition means 10 repeats the bits in the messages to be sent a certain number of times to improve signal reliability.

[0021] Thereafter, a signal point mapper 11 maps the signal from the bit repetition means 10 by, for example, changing all "0" bits to "+1" and all "1" bits to "-1" to allow further processing. The resulting signal is combined with a so-called "Walsh cover" signal and transmitted over the Reverse Activity (RA) channel to the mobile.

[0022] A conventional mobile receives the messages sent by the base station via the RA channel indicating that the current reverse link load is too large, and the mobile reduces the current packet data rate on the reverse link by one-half (1/2) so that the load on the reverse link is decreased.

SUMMARY OF THE INVENTION

[0023] A gist of the present invention involves the recognition by the present inventors of the drawbacks in the conventional art. In particular, conventional techniques (e.g., conventional mobile communications systems under the standards of IS-95, HDR, IMT-2000, etc.) for controlling data transmission rates between mobiles and a base station do not effectively consider the particular data transmission circumstances and channel conditions of each mobile station.

[0024] Conventional HDR systems do not employ effective power control techniques, thus there are difficulties in providing high-speed data transmissions to those mobiles located far from the base station requiring signal transmissions at a higher power compared with the signal transmissions for mobiles located in proximity to the base station requiring only low level power.

[0025] The conventional HDR system is disadvantageous in that, when the base station detects the load on the reverse link to be too large and feeds back this information via a reverse activity (RA) channel, the reverse link packet data rate is unconditionally reduced by one-half for all users (mobiles), and thus overall data throughput at each base station is undesirably reduced. The conventional art ignores the situations that individual mobiles have different requirements and should advantageously be controlled individually in a dedicated manner.

[0026] Additionally, the conventional HDR system is inefficient because no messages are sent to the mobiles to indicate that their packet data rates should be increased when the reverse link load is small.

[0027] Furthermore, the conventional art merely considers the reverse link load. However, in practical data packet transmission applications, the channel or link conditions, such as signal interference and transmission power requirements, and other communications environment factors effect data transmissions on the reverse link.

[0028] To address at least the above-identified conventional art problems, the present invention utilizes information fed back from the forward link for data packet transmission over the reverse link upon considering the particular data transmission circumstances and channel conditions of each mobile station and accordingly controlling the mobiles in a dedicated manner. By doing so, the data transmission rate over the reverse link is improved. More specifically, to improve reverse link data transmission rates, messages informing the mobile station to adjust (increase, decrease or maintain) its data transmission rate are sent from the base station in accordance with reverse link load information.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

Figure 1 shows a portion of a conventional reverse channel structure for sending transmission data rate increase information from a base station to a mobile;
Figure 2 shows a partial structure of a base station according to an embodiment of the present invention;
Figure 3 shows a partial structure of a mobile according to an embodiment of the present invention;
Figure 4 shows the details of certain relative portions of the determinator 24 in a base station, a portion of which is shown in Figure 2;
Figure 5 is a flow chart showing the main steps involved in transmitting transmission data rate adjust information to each mobile in a 1xEV-DV or 1xEV-DO system according to the present invention;
Figure 6 is a flow diagram of the method for controlling the data transmission rate in accordance with the present invention;
Figure 7 is a flow diagram of embodiment according to the present invention;
Figure 8 shows the updating procedure of the BS_RCV according to the present invention;
Figure 9 shows the procedures for generating rate control information using the BS_RCV values according to the present invention; and
Figure 10 shows an example of how the reverse link data rate is controlled using the BS_RCV values according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0030] Figure 2 shows a partial structure of a mobile according to an embodiment of the present invention. A mobile 20 comprises a reception processor 21, a demodulator 22, a transmission data rate controller 23, and a transmission processor 24. The reception processor 21 processes the signals received from a base station via a reception antenna A1. The demodulator 22 demodulates the signals processed by the reception processor 21. The transmission data rate controller 23 controls the transmission data rate based on the transmission data rate adjustment information in the signals processed by the demodulator 22. The transmission processor 24 transmits signals via a transmission antenna A2 to the base station in accordance with the control of the transmission data rate controller 23.

[0031] According to Figure 2, the mobile according to an embodiment of the present invention can comprise a determining means which determines a transmission energy level required for transmitting to a base station. Here, the determining means can comprise the transmission data rate controller 23 and the transmission processor 24, in their entirety or portions thereof.

[0032] Also, the mobile according to an embodiment of the present invention can comprise an adjusting means operatively connected with the determining means, which adjusts a data transmission rate based upon a comparison result received from the base station in a dedicated manner via a common channel, the comparison result being obtained by comparing the transmission energy level and an interference level of signals sent to the base station by the mobile stations. Here, the adjusting means can comprise the transmission data rate controller 23, and the transmission processor 24, in their entirety or portions thereof.

[0033] Furthermore, the mobile according to an embodiment of the present invention can comprise a transceiver operatively connected with the adjusting means, which transmits packet data on the reverse link in accordance with the adjusted data transmission rate. Here, the transceiver can comprise the reception processor 21, the demodulator 22, the transmission processor 24, and antennae A1 and A2, in their entirety or portions thereof.

[0034] Figure 3 shows a partial structure of a base station according to an embodiment of the present invention. A base station 30 comprises a reception processor 31, an interference level detector 32, a comparator 33, a determinator 34, and a transmission processor 35. The reception processor 31 processes (e.g., demodulates) the signals received from mobiles (not shown) via a reception antenna A3. The interference level detector 32 receives the processed signals from the reception processor 31 for estimating and/or detecting a level of signal interference related to the processed signals.

[0035] As understood by those skilled in the art, there are various types of signal interference between mobiles and base stations in mobile communications. For example, in the case of the reverse link, an important parameter is the rise in the level of the total amount of noise over the level of the thermal noise at a base station. This parameter is referred to as the "rise over thermal" (ROT). The rise over thermal (ROT) corresponds to the loading of the reverse link.

[0036] Typically, a communications system attempts to maintain the ROT near a predetermined value. If the ROT is too great, the range of the cell is reduced and the reverse link is less stable. A large ROT can also cause small changes in instantaneous loading that result in large excursions in the output power of the mobile station. When the ROT is considered to be too high (e.g., above a desired threshold level), the data transmission rate can be decreased or even interrupted until the reverse link is stabilized. In contrast, a low ROT can indicate that the reverse link is not heavily loaded, thus potentially wasting available capacity. Thus, if the ROT is considered to be too low (e.g., below a desired threshold level), the data transmission rate can be advantageously increased. It will be understood by those skilled in the art that methods other than measuring the ROT can be used in determining the loading of the reverse link.

[0037] After the interference level detector 32 detects the signal interference, the comparator 33 compares the detected level of signal interference with a threshold value in order to estimate (determine) the load on the reverse link. The determinator 34 determines a transmission data rate adjust information (e.g., increase, decrease or maintain) based on the reverse link load determined by the comparator 33, and determines a position of each mobile (i.e., a physical location of each mobile in the cell/sector served by the base station) based on the rate control bit (RCB) position in the channel slots. The RCB position in the channel slots allows mobiles to be discriminated from one another.

[0038] The transmission processor 35 modulates a transmission signal for sending the transmission data rate adjust information from the determinator 34 to each mobile, and transmits signals to each mobile via a transmission antenna A4. Here, the signals including the RCB information are transmitted to each mobile via a common channel. The common channel can be a known channel already used in conventional mobile communications. For example, the so-called "RA channel" can be employed in the present invention for transmitting signals and RCB information to each mobile. Alternatively, the signals including the RCB information are transmitted to each mobile via a newly established channel (Common Reverse Packet Data Control Channel - CRPDCCH), not currently existing in conventional mobile communications systems and techniques. Here, various conventional techniques may be employed in establishing a new type of channel, with a feature of the present invention being the use of rate control bit (RCB) in the frames (16 slots) transmitted to the mobiles.

[0039] According to Figure 3, a base station according to an embodiment of the present invention can comprise a

determining means, which determines an interference level of signals received from the mobile stations, and determines a transmission energy level required for each mobile station. Here, the determining means can comprise the interference level detector 32 and the comparator 33, in their entirety or portions thereof.

[0040] Also, a base station according to an embodiment of the present invention can comprise a comparing means operatively connected with the determining means, which compares the interference level with the transmission energy level to obtain a comparison result for each mobile station. Here, the comparing means can comprise the comparator 33 and determinator 34, in their entirety or portions thereof.

[0041] Additionally, a base station according to an embodiment of the present invention can comprise a transceiver operatively connected with the comparing means, which sends the comparison result via a common channel on a forward link to each mobile station in a dedicated manner in accordance with the comparing, and receives packet data on the reverse link in response to the sending. Here, the transceiver can comprise a reception processor 31, transmission processor 35, and antennae A3 and A4, in their entirety or portions thereof.

[0042] Accordingly, by using the general features of a mobile shown in Figure 2 and the features of a base station shown in Figure 3, data packets can be transmitted between the mobile and base station in accordance with the present invention. A more detailed description and explanation of the structural aspects and methods involved in the present invention are as follows.

[0043] Figure 4 shows the details of certain relative portions of the determinator 34 in the base station shown in Figure 2. The determinator 34 comprises a plurality of repeaters 41, a plurality of signal point mappers 42, a plurality of channel gain units 43, a pair of multiplexors 44, and a long code processor 45 having a long code generator 46, a decimator 47, and a relative offset calculator 48.

[0044] In the present invention, mobiles can be controlled via the so-called "I-channel" or "Q-channel" or both channels. Here, "I" refers to "in-phase" and "Q" refers to "quadrature," which are known terms in the art of digital signal modulation, in particular vector modulation. Vector modulation (of which quadrature amplitude modulation (QAM) is a popular type) is at the heart of most digital wireless (mobile) communication systems. QAM packs multiple data bits into single symbols, each of which modulates the carrier's amplitude and phase.

[0045] Of the reverse link load determined by the comparator 33, rate-control bits (e.g., RCBs) for each user (mobiles) 0 through N are sent to the determinator 34. Here, N denotes the number of users being controlled using the I-channel and/or Q-channel, which are also referred to as an "I-Arm" and a "Q-Arm." Based upon the RCBs transmitted to the mobiles during one data frame (the frame having 16 slots), the base station can control a plurality of mobiles using the I-channel, the Q-channel, or both.

[0046] The repeaters 41 of the determinator 34 receive the RCB data (including rate-control bits) related to a plurality of users (mobiles) 0 through N, and respectively processes these data for ultimately generating I-signals (X_I) and/or Q-signals (X_Q).

[0047] For example, 12, 24, 48, 96, 192 or 384 mobiles can be controlled by the base station according to the present invention. If only the I-channel or the Q-channel is used, 12, 24, 48, 96 or 192 mobiles can be controlled. If both the I-channel and Q-channel are used, 24, 48, 96, 192 or 384 mobiles can be controlled. When either the I-channel or the Q-channel is used to control 12 mobiles, the repeater 41 repeats the bits in the messages to be sent 16 times to improve signal reliability. In this manner, for respectively controlling 24, 48, or 96 mobiles, 8, 4, or 2 repetitions are performed, respectively. For controlling 192 mobiles, no repetitions are made. Namely, instruction signals are sent to the mobiles without performing any bit repetitions. In a similar manner, when both the I-channel and the Q-channel are used, for respectively controlling 24, 48, 96 or 192 mobiles, 16, 8, 4, or 2 repetitions are performed. For controlling 384 mobiles, instruction signals are sent to the mobiles without performing any bit repetitions.

[0048] Although a particular number of mobiles capable of being controlled have been exemplified above based upon there being 16 slots in a frame to be transmitted, those skilled in the art would understand that other specific number of mobiles could also be handled according to the present invention depending upon the particular frame size and number of slots therein.

[0049] Then, the signal point mappers 42 map the signals received from the repeaters 41 by, for example, changing all "0" bits to "+1", all "1" bits to "-1", and no symbol bits to "0" to allow further processing.

[0050] Here, the signal point mapping techniques can generally be performed in a variety of ways, as understood by those skilled in the art. However, a preferred method in signal point mapping according to the present invention involves a particular technique of processing the RCBs. Namely, based upon the transmission data rate adjust information, if the current transmission data rate is to be increased, the base station sets the RCB to "INCREASE" and if the current transmission data rate is to be decreased, the base station sets the RCB to "DECREASE" Also, if current transmission data rate is to be maintained, no RCB information is transmitted by the base station to the mobile.

[0051] Also, the number of slots used for processing a symbol depends upon the number of users N. For example, if N = 12, 1 symbol per 1 slot is processed. Also, for N = 24, 48, 96 or 192, 1 symbol / 2 slots, 1 symbol / 4 slots, 1 symbol / 8 slots, and 1 symbol / 16 slots are processed, respectively, as indicated in Figure 4.

[0052] Thereafter, the channel gain units 43 further process each signal received from the signal point mappers 42,

respectively. Namely, channel gain amplification is performed and the processed signals are sent to the multiplexers (MUX) 44, the features of which are explained further below. Here, the channel gain amplifying techniques can generally be performed in a variety of ways, as understood by those skilled in the art.

[0053] Additionally, the RCB data related to I-Q signal generation includes initial offset values (0 to N-1) assigned to each user (mobile) and which determine the position of each mobile (based on the RCB position in the channel slots). Here, the initial offset values are determined (or generated) during a so-called "negotiation" process between mobiles and the base station. Of the initial offset values, "0" indicates the first position among the channel slots, while "N-1" indicates the last position.

[0054] The determinator 34 also includes a long code processor 45 comprising a long code generator 46, a decimator 47 and a relative offset calculator 48. The long code processor 45 receives a long code mask for the common reverse packet data control channel (CRPDCCH) and outputs relative offset values used for generating an I-signal and a Q-signal. Here, for the relative offset values, the RCB positions allocated to each mobile are preferably randomized. Namely, the RCBs are inserted into different slot positions in each frame. As such, the RCB position in the channel slots allows mobiles to be discriminated from one another.

[0055] Finally, the multiplexers (MUX) 44 respectively combine the initial offset values assigned to each user with the relative offset values (generated by the long code processor 45), and the processed signals from the channel gain units 43, so that the RCB positions in the channel slots are determined, As a result, the multiplexed signals X_I and X_Q for the I-channel, the Q-channel, or both are outputted from the determinator 34 for further processing at the transmission processor 35 and subsequent transmission to the mobiles.

[0056] Figure 5 is a flow chart showing the principle steps involved in transmitting transmission data rate adjust information to each mobile in a 1xEV-DV or 1xEV-DO system according to an embodiment of the present invention. First, the base station detects and determines a level of interference among all communication traffic channels (S51). The detected interference level is compared with a threshold so that the load on the reverse link can be approximated (S52, S53). Transmission data rate adjust information is determined by the reverse link load and information regarding the distance from each mobile to the base station, and as previously explained in view of Figure 4, the multiplexers 41, 41' combine the initial offset values (from the I-signals and Q-signals) with the relative offset values (from decimating the codes from the long code generator 46) so that the RCBs positions in the channel slots are determined for discriminating each mobile from one another (S54). Finally, the RCBs are transmitted to the mobiles via a common channel, which operate in a dedicated manner (i.e., exclusively) for each mobile (S55).

[0057] Upon receiving the RCBs from the base station, the mobiles preferably adjust their transmission data rates in increments for gradual increasing or decreasing. Then, the mobiles may inform the base station of the adjusted transmission data rate which they intend to use by sending to the base station a reverse rate indicator (RRI). Thereafter, packet data are transmitted to the base station on the reverse link at the adjusted data rate. Accordingly, employing the techniques of the present invention can advantageously increase data throughput.

[0058] The instructions (based upon RCBs) sent by the base station to the mobiles for adjusting (increasing, decreasing or maintaining) the transmission data rate of a mobile during the reverse link will be referred to as "RC instructions." In the present invention, the base station preferably sends RC instructions to the mobiles during a single frame, for controlling the transmission date rate of the mobiles during the next frame. However, those skilled in the art can understand that the sending of RC instructions may extend into a subsequent frame in certain situations.

[0059] Figure 6 shows a flow diagram of the method for controlling the data transmission rate in accordance with the present invention. For controlling a data transmission rate on a reverse link in a mobile communications system having a plurality of base stations and a plurality of mobile stations, a first step of determining an interference level at a base station due to signals from the mobile stations served by the base station is performed (S60). Also, a step of determining a transmission energy level required for each mobile station is performed (S62). Next, the interference level is compared with the transmission energy level to obtain a comparison result for each mobile station (S64).

[0060] Thereafter, the comparison result is transmitted by the base station to the mobile via a common channel on a forward link in a dedicated manner (S66). Here, the base station transmits respective comparison results to each mobile in a dedicated manner. In other words, the base station sends a particular comparison result to a particular mobile (having a particular interference level and required transmission energy level previously determined) so that each mobile is individually controlled to have an appropriate data transmission rate.

[0061] Subsequently, each mobile adjusts its current data transmission rate based upon the comparison result sent from the base station via a common channel on a forward link in a dedicated manner (S68). Finally, packet data are transmitted on the reverse link from a mobile to the base station in accordance with the adjusted data transmission rate (S69).

[0062] In other words, a method for controlling a data transmission rate on a reverse link according to the present invention can comprise the steps of determining an interference level at a base station due to signals from the mobile stations served by the base station; determining a transmission energy level required for each mobile station; comparing the interference level with the transmission energy level to obtain a comparison result for each mobile station; and

adjusting a data transmission rate for each mobile station based upon the comparison result sent via a common channel on a forward link to each mobile station in a dedicated manner.

[0063] Also, a method for controlling a data transmission rate on a reverse link according to the present invention can comprise the steps of determining an interference level of signals received from the mobile stations; determining a transmission energy level required for each mobile station; comparing the interference level with the transmission energy level to obtain a comparison result for each mobile station; and sending the comparison result via a common channel on a forward link to each mobile station in a dedicated manner in accordance with the comparing.

[0064] Additionally, a method for controlling a data transmission rate on a reverse link according to the present invention can comprise the steps of determining a transmission energy level required for transmitting to the base station; adjusting a data transmission rate based upon a comparison result received from the base station in a dedicated manner via a common channel, the comparison result being obtained by comparing the transmission energy level and an interference level of signals sent to the base station by the mobile stations; and transmitting packet data on the reverse link in accordance with the adjusting.

[0065] The above-described techniques of employing RCB according to an embodiment of the present invention improve the conventional techniques (e.g., conventional communications systems under the standards of IS-95, HDR, IMT-2000, etc.) for controlling transmission data rates between mobiles and a base station. However, the present inventors recognized that additional improvements are also possible.

[0066] For example, the particular communication conditions of each mobile may be further considered in addition to the overall signal interference at the base station (including ROT parameters) described previously hereinabove. By considering the factors at each mobile, different mobiles can receive different instructions to adjust their respective transmission data rates in a different manner, instead of all mobiles receiving the same instruction to increase or decrease their transmission data rates by an equal amount.

[0067] In conventional techniques, each mobile performs an internal test upon receiving a transmission data rate adjust instruction (an RA instruction) from its base station, instead of immediately adjusting its current transmission data rate. In other words, each mobile further considers its own communications conditions prior to adjusting its transmission data rate.

[0068] The internal test conducted by the mobile involves the determination of the probability that the data transmission rate in the next frame will likely increase or decrease. Namely, if the current data transmission rate is relatively low for the current frame, there is a relatively high probability that the data transmission rate should be increased in the next frame, and there is a relatively low probability that the data transmission rate should be decreased in the next frame.

[0069] For example, suppose that a communications system can transmit data at five different rates: 9,600 bps; 19,200 bps; 38,400 bps; 76,800 bps; and 153,600 bps. Assuming that a first mobile (A) is transmitting data at 19,200 bps during the current frame, while a second mobile (B) is transmitting data at 76,800 bps in the current frame. Then, if the base station sends to the mobiles that it is serving, an instruction to increase the current data transmission rate, mobile A has a greater probability of operating at a higher data transmission rate compared to mobile B. In contrast, if the base station sends to the mobiles that it is serving, an instruction to decrease the current data transmission rate, mobile B has a greater probability of operating at a lower data transmission rate compared to mobile A.

[0070] In other words, a method for controlling a data transmission rate on a reverse link according to the present invention can comprise the steps of detecting a total interference amount received by a base station; determining a transmission energy level required by a mobile station based upon a cell interference probability of each mobile station; receiving transmittable data rate information of each mobile station; and generating data rate control information in accordance with the total interference amount, the transmission energy level, and the data rate information for controlling a data transmission rate on a reverse link.

[0071] The present invention considers the channel condition or state for each mobile, the valid data rate for transmitting within a frame, and the signal interference at the base station, such that the base station individually controls the reverse link data rate for each mobile in a dedicated manner. To achieve this control, various parameters for the base station and mobiles can be used. These parameters are defined as follows.

1) Mobile station priority (MS_PRI)

[0072] MS_PRI is a parameter used for determining a probability of cell interference of each mobile, and is obtained by using the following equation (1):

$$MS\_PRI = \frac{\alpha_j}{\sum^{All} \alpha_i - \alpha_j} \approx \frac{\beta_j}{\sum^{All} \beta_i - \beta_j}, \qquad (1)$$

[0073] This parameter can be calculated by the base station itself or by the mobile, which informs the base station of the MS_PRI value in a periodic manner or whenever the channel environment of the mobile changes.

[0074] In equation (1), α_i denotes the reverse link channel gain between the mobile and the i-th base station, while α_j denotes the reverse link channel gain between the mobile and the j-th base station which has the largest channel gain of all base stations. Also, β_i denotes the forward link channel gain between the mobile and the i-th base station, while β_j denotes the forward link channel gain between the mobile and the j-th base station which has the largest channel gain of all base stations.

[0075] When fading is not considered (i.e., ignored), the channel gain of the forward link and the channel gain of the reverse link can be considered to be the equivalent. Thus, the approximation:

$$\frac{\alpha_j}{\sum^{All} \alpha_i - \alpha_j} \approx \frac{\beta_j}{\sum^{All} \beta_i - \beta_j}$$

of equation (1) is satisfied.

[0076] Also, assuming that the total transmission power of all base stations are approximately the same, when the total transmission power of the base station is multiplied to the channel gain (i.e., multiply the total transmission power of the base station by β_i), the resulting value is equivalent to the total signal power received by one mobile from the i-th base station (i.e., Ior). Thus, the approximation: $MS\_PRI \approx \frac{max\_Ior_j}{Io - max\_Ior_j}$ of equation (1) is satisfied, and the MS_PRI value can be determined.

[0077] In equation (1), Io denotes the total sum of the signal power from all base stations received by the mobile (i.e., sum of Ior received from all base stations), and max_Ior_j denotes the signal power received from the j-th base station which has the strongest reception signal power of all base stations.

[0078] The MS_PRI value, indicates in an inversely proportional manner, how a particular mobile, on average, causes cell interference to other cells. A large MS_PRI value means that the probability of causing cell interference is low, while a small MS_PRI value means that the probability of causing cell interference is high. In other words, a large MS_PRI value indirectly indicates a high probability that the mobile is located near a base station or that the mobile is located in a place where the channel state is satisfactory, while a small MS_PRI value denotes the opposite.

[0079] The MS_PRI value can be calculated in at least the following three different methods.

[0080] First, the mobile calculates the MS_PRI value using the Io value detected from the total sum of signal power received from all base stations, and the max_Ior value of the base stations having the greatest reception signal power, and thereafter the MS_PRI value is directly transmitted to the base station.

[0081] Second, the mobile sends to the appropriate base station, the Ec/Io value of the pilot signal (Ec) power received from each base station using the pilot signal measurement message (PSMM) reported to the base station. Then, the base station receiving the Ec/Io value uses this to calculate the MS_PRI value.

[0082] Third, when there exists a reverse link channel (such as the data rate control (DRC) channel in 1xEV-DO systems) for informing the channel state of the forward link, the base station uses the forward link channel state value (such as the Ec/Nt of the pilot signal (Ec)) transmitted via this channel to calculate the MS_PRI value.

2) Mobile station reverse control value (MS_RCV)

[0083] The MS_RCV value is a parameter used for determining the transmission energy value necessary for each mobile,). First, a function *f*(x) is defined, a calculation using the following equation (2) is performed.

$$MS\_RCV = f(Current\_Assigned\_Data\_Rate)[dB] - \alpha * MS\_PRI[dB] \qquad (2)$$

[0084] Here, the MS_RCV value may be indicated in units of dB. Also, "Current_Assigned_Data_Rate" denotes the data rate being used in the current transmission frame, while *f*(x) is a function related to the reception energy necessary

for normally receiving data from a base station at a data rate of x. For example, if the "Current_Assigned_Data_Rate" is 9600, we get a function $f(9600) = 4dB$, which calculates in advance, a reception energy level for each data rate.

[0085] Thus, the MS_RCV value applies cell interference probabilities to the reception energy necessary for each mobile. Thus, the present invention employing the MS_RCV value can minimize the occurrence of cell interference by using a relatively low transmission energy level (transmit power) satisfy the reception energy level (reception power) requested by the base station, for those mobiles that are close to the base station or having a strong channel link.

[0086] In general, as the data rate increases, the reception energy required for each mobile also increases. Thus, as the "Current_Assigned_Data_Rate" is higher, the MS_RCV value increases.

[0087] In equation (2), the MS_PRI value in the term "α * MS_PRI" denotes the probability of causing interference to other cells. If the MS_PRI value is small (i.e., when there is a high probability of causing interference to other cells), the MS_RCV value becomes large.

[0088] Also, the value "α", which can be adjusted to control how the MS_PRI effects the MS_RCV, is a variable that controls the "fairness" between users (mobiles). The base station adjusts the α value so that all mobiles are guaranteed to have an appropriate data rate. For example, when α =0, the channel conditions for the mobile are not considered and the degree of fairness between the users (mobiles) is at a maximum. In contrast, as the α value increases, the channel conditions of each mobile have more effect on the MS_RCV value.

[0089] In summary, as the data rate of the current transmission is higher, and as the MS-PRI value is lower (i.e., as the probability of causing other cell interference is greater), the MS_RCV value increases. The base station calculates and manages the MS_RCV value for each active mobile.

3) Mobile station Rate Increase Available Bit (MS_IAB)

[0090] The MS_IAB value is a parameter to provide data rate information for valid data that can be transmitted in the next frame by the mobile. The MS_IAB value has two states, "increase" and "unchanged," based on the following conditions.

[0091] If all the following conditions are met, the MS_IAB value is set as "increase," while if any one of these conditions is not met, the value is set as "unchanged."

I. When transmission power margin (i.e., remaining transmission power) is above a certain level;
II. When the number of bits in the transmission buffer is above a certain level; and
III. When the data rate of the current transfer (i.e., Current_Assigned_Data_ Rate) is below a maximum data rate (i.e., MAX_Data_Rate) set by the system.

[0092] As shown in Figure 7, which is a flow diagram of embodiment according to the present invention, the base station uses the above-identified parameters (i.e., MA_PRI, MS_RCV, and MS_IAB) for controlling the data transmission rate of a mobile.

[0093] The base station receives the MS_PRI value reported from the mobile in a periodic manner or whenever the channel conditions of the mobile change, or directly calculates the MS_PRI value for updating thereof. Here, the MS_PRI value is initially set at 0 and updated thereafter (S70).

[0094] The base station uses the thusly obtained MS_PRI value and the data rate at which the mobile is transmitting, i.e., the "Current_Assigned_Data_Rate", for calculating and managing MS_RCV values for those mobiles that are in an active state with regard to the base station (S71).

[0095] Also, the base station detects the total interference (e.g., the rise over thermal (ROT) value) based on the total energy of signals received at the base station (S72). Thereafter, each mobile transmits the MS_IAB value to the base station in every frame (S73).

[0096] The base station uses the MS_RCV and MS_IAB values to generate a rate control bit (RCB) for controlling the data rate of each mobile (S74), and the RCB is transmitted to each mobile (S75). Here, the RCB can include three types of commands; an increase command for increasing the data rate of the mobile, a decrease command for decreasing the data rate, and a command for not changing the data rate.

[0097] If the ROT detected by the base station is deemed to be satisfactory (e.g., ROT < ROT_TH1, where ROT_TH1 is a first threshold value), the MS_RCV value is accordingly below a threshold value (RCV_TH), and of the mobiles having their MS_IAB values set as "increase," the RCB values for certain mobiles are set as "increase" while the RCB values for the remaining mobiles are set as "unchanged."

[0098] However, if it is determined that the ROT detected by the base station is maintained with a range (ROT_TH1 ~ ROT_TH2) set by the system, the RCB values for all mobiles are set to "unchanged."

[0099] If the ROT detected by the base station is deemed to be unsatisfactory (e.g., ROT > ROT_TH2, where ROT_TH2 is a second threshold value), for those mobiles having a MS_RCV value exceeding the RCV-TH value, their RCB values are set as "decrease" while the RCB values for the remaining mobiles are set to "unchanged."

[0100] In the above method, the particular number of mobiles having their RCB values set as "increase," "decrease," or "unchanged" depends on various factors such as the actual implementation environment, system performance, capacity, operation purpose, and the like. In a particular embodiment, the following algorithm is presented to show how the above features may be applied an implemented.

[0101] First, a parameter BS_RCV (Base Station Rate Control Value) is defined to determine the total number of mobiles. Here, for the BS_RCV, the lowest MS_RCV value of the MS_RCV values (calculated at a base station or reported from a mobile) at a data rate of 9600 bps is set as its initial value. Thus, the BS_RCV is defined to limit the selective range of the MS_RCV such that only those mobiles having an MS_RCV value being above or below a certain level receive RCB increase or decrease data rate control information.

[0102] Figure 8 shows the updating procedure of the BS_RCV according to the present invention. The base station determines the total interference amount (i.e., ROT) received by the base station in the unit of time having a particular period. The base station then uses the detected ROT value to update the BS_RCV. If the detected ROT value is below ROT_TH1, BS_RCV increases by Δ_1, and if the ROT value is below ROT_TH2, BS_RCV decreases by Δ_2. However, if the ROT is maintained within a range between ROT_TH1 and ROT_TH2, the BS_RCV value is maintained at its previous value.

[0103] Figure 9 shows the procedures for generating rate control information using the BS_RCV values according to the present invention. First, the base station updates the BS_RCV value using the detected ROT value as shown in Figure 8.

[0104] Then, the base station generates an RCB for each mobiles based on the following conditions using the MS_RCV value, the BS_RCV value, and the MS_IAB value received from the respective mobile. If (MS_RCV + λ) < BS_RCV, and MS_IAB = "increase" are satisfied, the RCB is set as "increase." But, if MS_RCV > BS_RCV, then RCB is set as "decrease." However, if (MS_RCV + λ) < BS_RCV and MS_IAB "increase," or if MS_RCV BS_RCV (MS_RCV + λ), the RCB is set as "unchanged." As such, the present invention employs the "λ" value to more appropriately control the RCB value setting allocation to better reflect the communications environment.

[0105] Figure 10 shows an example of how the reverse link data rate is controlled using the BS_RCV values according to the present invention. Namely, the steps for controlling the data rate of a mobile by the base station in an exclusive or dedicated manner are shown.

[0106] The base station updates the MS_PRI value by receiving a MS_PRI value from the mobile reported therefrom periodically, or whenever the channel conditions of the mobile change, or by directly calculating a MS_PRI value at the base station itself. The MS_PRI value is initially set as 0 and updated thereafter (S100).

[0107] The base station uses the MS_PRI value and the data rate used by the mobile for transmission (i.e., the "Current_Assigned_Data_Rate") to calculate and manage the MS_RCV values of all mobiles being in active state with respect to the base station (S102).

[0108] The base station determines the total energy of the signals received thereof (i.e. the total interference amount, such as ROT) for each time interval having a certain period (S104).

[0109] Then, the base station updates the BS_RCV values using the method shown previously in Figure 8 (S106). Thereafter, each mobile, for each frame, transmits the MS_IAB value to the base station (S108).

[0110] The base station then generates rate control bit (RCB) for controlling the data rate of each mobile using the MS_RCV, MS_IAB, and BS_RCV values (S110), and the RCB values are transmitted to each mobile (S112).

[0111] A respective mobile receives RCB values from all active base stations (S114), and generates a Combined RCB from the received RCB values for controlling the data rate of the next frame accordingly (S116). A method for combining the RCB values received from all active base stations is as follows:

[0112] If all received RCB values are set as "increase," the combined RCB is set as "increase." If any one of the RCB values is set as "decrease," the combined RCB is set as "decrease." In all other situations, the combined RCB is set as "unchanged."

[0113] In other words, a method for controlling a data transmission rate on a reverse link according to the present invention can comprise the steps of determining a channel condition value of each mobile station by a pilot channel average power level and a data transmission rate; comparing the channel condition value with a transmission threshold of a base station calculated by an interference at the base station; and adjusting a data transmission rate for each mobile station based upon the comparison result sent via a channel on a forward link to each mobile station in a dedicated manner.

[0114] Additionally, a method for controlling a data transmission rate on a reverse link according to the present invention can comprise the steps of determining a total interference level of signals received from one or more mobile stations; determining a data transmission control threshold value according to the total interference level; determining a transmission condition value by receiving a reverse link data transmission rate and a transmitted pilot signal strength from the one or more mobile stations; generating reverse link data transmission rate commands by comparing the transmission condition value with the data transmission control threshold value; and transmitting data to each mobile station in accordance with the generated reverse link data transmission rate commands.

[0115] Furthermore, a method for controlling a data transmission rate on a reverse link according to the present invention can comprise the steps of determining a total interference level of signals received at a base station; receiving a transmission pilot signal strength and a reverse link data transmission rate from a mobile station; and generating and sending to the mobile station, a reverse link data transmission rate command using the total interference level, the transmission pilot signal strength, and the a reverse link data transmission rate.

[0116] As described above, in accordance with the present invention, the data rate control information is generated by considering not only the total interference amount received by the base station, but also the signal reception conditions at each mobile. Thus, exclusive or dedicated data rate control for each mobile is possible. Accordingly, improved data transmissions being more appropriate to the channel conditions of each mobile is achieved, and data throughput is significantly gained. Also, base station management is advantageously improved, as the base station can accurately control the loading on the reverse link.

[0117] The present invention has been described above with respect to variations in data transmission techniques between a base station and mobile station served by the base station, focusing on transmissions on the reverse link in a next generation CDMA system. However, it will be understood that the invention can be advantageously applied to other situations including transmissions on other types of channels and other mobile communication systems being developed for handling data packet transmissions.

[0118] This specification describes various illustrative embodiments of a method and device of the present invention. The scope of the claims is intended to cover various modifications and equivalent arrangements of the illustrative embodiments disclosed in the specification. Therefore, the following claims should be accorded the reasonably broadest interpretation to cover modifications, equivalent structures, and features that are consistent with the spirit and scope of the invention disclosed herein.

Claims

1. A method for controlling a data transmission rate on a reverse link in a mobile communications system having a plurality of base stations and a plurality of mobile stations, the method comprising:

    determining an interference level at a base station due to signals from the mobile stations served by the base station;
    determining a transmission energy level required for each mobile station;
    comparing the interference level with the transmission energy level to obtain a comparison result for each mobile station; and
    adjusting a data transmission rate for each mobile station based upon the comparison result sent via a common channel on a forward link to each mobile station in a dedicated manner.

2. The method of claim 1, further comprising a step of generating a rate control bit (RCB) based on the comparison result, the RCB indicating how a current data transmission rate of a respective mobile station is to be adjusted.

3. The method of claim 2, wherein the RCB is inserted into certain bit positions in a channel slot of the common channel.

4. The method of claim 1, wherein the interference level is based on a rise over thermal (ROT) parameter.

5. The method of claim 1, wherein the interference level is based on a probability of cell interference of each mobile station.

6. The method of claim 1, wherein the transmission energy level is based on a currently assigned data transmission rate.

7. The method of claim 1, wherein the comparing is performed by using a data rate of valid data that can be transmitted in a next frame.

8. The method of claim 1, wherein the comparison result includes a data rate control parameter generated by each base station indicating whether a particular mobile station should increase, decrease or maintain its current data transmission rate.

9. The method of claim 8, wherein each mobile station receives a data rate control parameter from all active base

stations to generate a combined data rate control parameter.

10. The method of claim 9, wherein the combined data rate control parameter indicates that a particular mobile station should increase its current data transmission rate if all data rate control parameters received from all active base stations indicate a data transmission rate increase, and that a particular mobile station should decrease its current data transmission rate if at least one data rate control parameter from at least one active base station indicates a data transmission rate decrease.

11. The method of claim 3, wherein the common channel is newly defined.

12. A method for controlling a data transmission rate on a reverse link in a mobile communications system having a plurality of base stations and a plurality of mobile stations, the method comprising:

determining an interference level of signals received from the mobile stations;
determining a transmission energy level required for each mobile station;
comparing the interference level with the transmission energy level to obtain a comparison result for each mobile station; and
sending the comparison result via a common channel on a forward link to each mobile station in a dedicated manner in accordance with the comparing.

13. The method of claim 12, further comprising a step of generating a rate control bit (RCB) based on the comparison result, the RCB indicating how a current data transmission rate of a respective mobile station is to be adjusted.

14. The method of claim 13, wherein the RCB is inserted into certain bit positions in a channel slot of the common channel.

15. The method of claim 12, wherein the interference level is based on a rise over thermal (ROT) parameter.

16. The method of claim 12, wherein the interference level is based on a probability of cell interference of each mobile station.

17. The method of claim 12, wherein the transmission energy level is based on a currently assigned data transmission rate.

18. The method of claim 12, wherein the comparison result includes a data rate control parameter generated by each base station indicating whether a particular mobile station should increase, decrease or maintain its current data transmission rate.

19. The method of claim 14, wherein the common channel is newly defined.

20. A method for controlling a data transmission rate on a reverse link in a mobile communications system having a plurality of base stations and a plurality of mobile stations, the method comprising:

determining a transmission energy level required for transmitting to the base station;
adjusting a data transmission rate based upon a comparison result received from the base station in a dedicated manner via a common channel, the comparison result being obtained by comparing the transmission energy level and an interference level of signals sent to the base station by the mobile stations; and
transmitting packet data on the reverse link in accordance with the adjusting.

21. The method of claim 20, wherein the interference level is based on a probability of cell interference of each mobile station.

22. The method of claim 20, wherein the comparing is performed by using a data rate of valid data that can be transmitted in a next frame.

23. The method of claim 20, wherein each mobile station receives a data rate control parameter from all active base stations to generate a combined data rate control parameter.

24. The method of claim 23, wherein the combined data rate control parameter indicates that a particular mobile station should increase its current data transmission rate if all data rate control parameters received from all active base stations indicate a data transmission rate increase, and that a particular mobile station should decrease its current data transmission rate if at least one data rate control parameter from at least one active base station indicates a data transmission rate decrease.

25. The method of claim 20, wherein the common channel is newly defined.

26. A base station apparatus in a mobile communications system for controlling a data transmission rate on a reverse link, the apparatus comprising:

a determining means which determines an interference level of signals received from the mobile stations, and determines a transmission energy level required for each mobile station;
a comparing means operatively connected with the determining means, which compares the interference level with the transmission energy level to obtain a comparison result for each mobile station; and
a transceiver operatively connected with the comparing means, which sends the comparison result via a common channel on a forward link to each mobile station in a dedicated manner in accordance with the comparing, and receives packet data on the reverse link in response to the sending.

27. The apparatus of claim 26, wherein the base station further generates a rate control bit (RCB) based on the comparison result, the RCB indicating how a current data transmission rate of a respective mobile station is to be adjusted.

28. The apparatus of claim 27, wherein the base station inserts the RCB into certain bit positions in a channel slot of the common channel.

29. The apparatus of claim 26, wherein the interference level determined by the determining means is based on a rise over thermal (ROT) parameter.

30. The apparatus of claim 26, wherein the interference level determined by the determining means is based on a probability of cell interference of each mobile station.

31. The apparatus of claim 26, wherein the transmission energy level determined by the determining means is based on a currently assigned data transmission rate.

32. The apparatus of claim 26, wherein the comparison result includes a data rate control parameter generated by each base station indicating whether a particular mobile station should increase, decrease or maintain its current data transmission rate.

33. The apparatus of claim 28, wherein the common channel is newly defined.

34. The apparatus of claim 26, wherein the mobile communications system is a next generation code-division multiple access (CDMA) system. (apparatus)

35. A mobile station apparatus in a mobile communications system for controlling a data transmission rate on a reverse link, the apparatus comprising:

a determining means which determines a transmission energy level required for transmitting to a base station;
an adjusting means operatively connected with the determining means, which adjusts a data transmission rate based upon a comparison result received from the base station in a dedicated manner via a common channel, the comparison result being obtained by comparing the transmission energy level and an interference level of signals sent to the base station by the mobile stations; and
a transceiver operatively connected with the adjusting means, which transmits packet data on the reverse link in accordance with the adjusted data transmission rate.

36. A method for controlling a data transmission rate on a reverse link in a mobile communications system having a plurality of base stations and a plurality of mobile stations, the method comprising:

detecting a total interference amount received by a base station;
determining a transmission energy level required by a mobile station based upon a cell interference probability of each mobile station;
receiving transmittable data rate information of each mobile station; and
generating data rate control information in accordance with the total interference amount, the transmission energy level, and the data rate information for controlling a data transmission rate on a reverse link.

37. The method of claim 36, wherein the base station receives the cell interference probability reported from each mobile station, or calculates the cell interference probability on its own.

38. The method of claim 36, further comprising:

preparing, by allocating, a transmission energy required for a data rate of a current transmission frame for each mobile station; and
calculating the transmission energy level using the cell interference probability applied to the transmission energy required for a data rate of a current transmission frame for each mobile station.

39. The method of claim 36, wherein the data rate information is set as "increase" if a remaining transmission power of each mobile is above a threshold, if the number of bits to be sent within a transmission buffer is above a threshold, and if the data rate of a current transmission is below a maximum data rate.

40. The method of claim 36, wherein the data rate information is set as "unchanged" if at most, two conditions of a group comprising: if a remaining transmission power of each mobile is above a threshold, if the number of bits to be sent within a transmission buffer is above a threshold, and if the data rate of a current transmission is below a maximum data rate, are satisfied.

41. A method for controlling a data transmission rate on a reverse link in a mobile communications system having a plurality of base stations and a plurality of mobile stations, the method comprising:

determining a channel condition value of each mobile station by a pilot channel average power level and a data transmission rate;
comparing the channel condition value with a transmission threshold of a base station calculated by an interference at the base station; and
adjusting a data transmission rate for each mobile station based upon the comparison result sent via a channel on a forward link to each mobile station in a dedicated manner.

42. A method for controlling a data transmission rate on a reverse link in a mobile communications system having a plurality of base stations and a plurality of mobile stations, the method comprising:

determining a total interference level of signals received from one or more mobile stations;
determining a data transmission control threshold value according to the total interference level;
determining a transmission condition value by receiving a reverse link data transmission rate and a transmitted pilot signal strength from the one or more mobile stations;
generating reverse link data transmission rate commands by comparing the transmission condition value with the data transmission control threshold value; and
transmitting data to each mobile station in accordance with the generated reverse link data transmission rate commands.

43. The method of claim 42, wherein the data transmission control threshold is either maintained if the total interference level is within a fixed range, increased if the total interference level is less than the fixed range, or decreased the total interference level is greater than the fixed range.

44. The method of claim 42, wherein during the comparison of the transmission condition value, which corresponds to the transmitted pilot signal strength and the reverse link data transmission rate, with the threshold value, a decrease rate bit is formed if the transmission condition value is greater than the threshold value, an increase rate bit is formed if the transmission condition value is smaller than twice the threshold value, and a maintain rate bit is formed for the current data transmission for conditions other than those for forming the decrease rate bit or the increase rate bit.

45. A method for controlling a data transmission rate on a reverse link in a mobile communications system having a plurality of base stations and a plurality of mobile stations, the method comprising:

determining a total interference level of signals received at a base station;
receiving a transmission pilot signal strength and a reverse link data transmission rate from a mobile station; and
generating and sending to the mobile station, a reverse link data transmission rate command using the total interference level, the transmission pilot signal strength, and the a reverse link data transmission rate.

FIG. 1

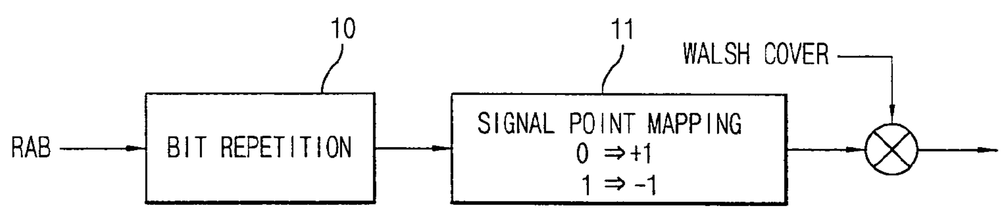

10
11
WALSH COVER
RAB
BIT REPETITION
SIGNAL POINT MAPPING
0 ⇒+1
1 ⇒ -1

FIG. 2

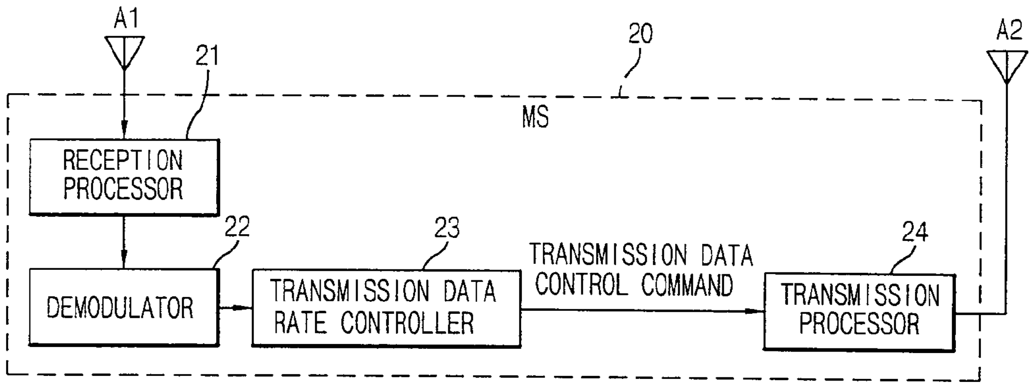

A1
21
20
A2
MS
RECEPTION PROCESSOR
22
23
TRANSMISSION DATA CONTROL COMMAND
24
DEMODULATOR
TRANSMISSION DATA RATE CONTROLLER
TRANSMISSION PROCESSOR

FIG. 3

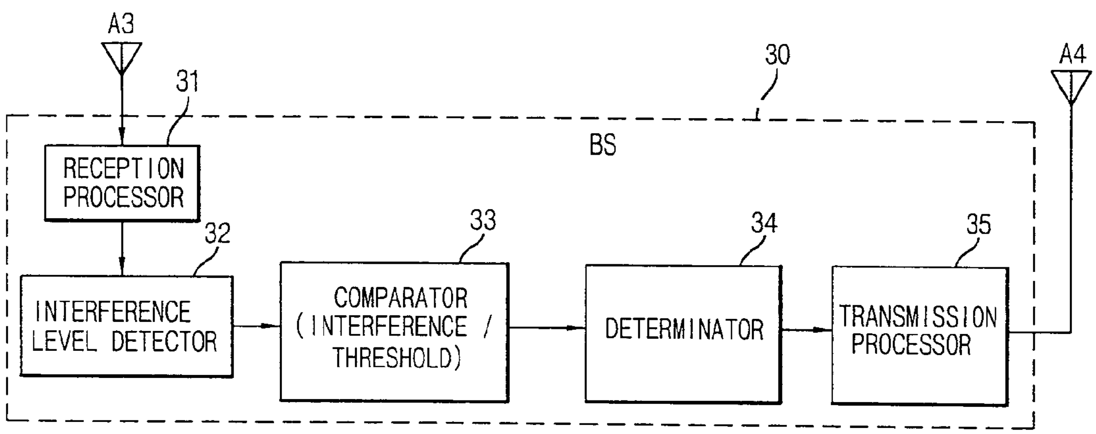

A3
31
30
A4
BS
RECEPTION PROCESSOR
32
33
34
35
INTERFERENCE LEVEL DETECTOR
COMPARATOR (INTERFERENCE / THRESHOLD)
DETERMINATOR
TRANSMISSION PROCESSOR

FIG. 4

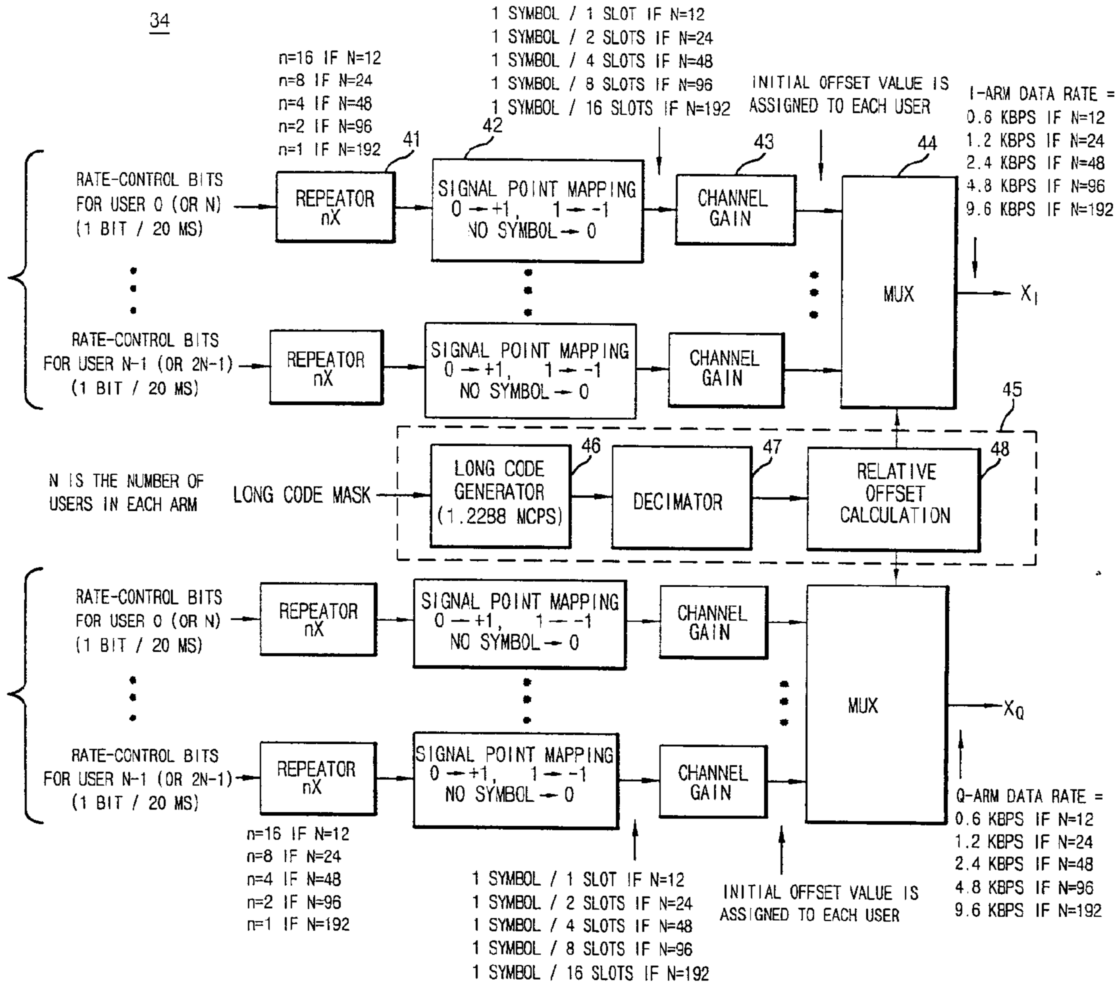

34
n=16 IF N=12
n=8 IF N=24
n=4 IF N=48
n=2 IF N=96
n=1 IF N=192
1 SYMBOL / 1 SLOT IF N=12
1 SYMBOL / 2 SLOTS IF N=24
1 SYMBOL / 4 SLOTS IF N=48
1 SYMBOL / 8 SLOTS IF N=96
1 SYMBOL / 16 SLOTS IF N=192
INITIAL OFFSET VALUE IS ASSIGNED TO EACH USER
I-ARM DATA RATE =
0.6 KBPS IF N=12
1.2 KBPS IF N=24
2.4 KBPS IF N=48
4.8 KBPS IF N=96
9.6 KBPS IF N=192
41
42
43
44
RATE-CONTROL BITS FOR USER 0 (OR N) (1 BIT / 20 MS)
REPEATOR nX
SIGNAL POINT MAPPING 0 → +1, 1 → -1 NO SYMBOL → 0
CHANNEL GAIN
MUX
X_I
RATE-CONTROL BITS FOR USER N-1 (OR 2N-1) (1 BIT / 20 MS)
45
46
47
48
N IS THE NUMBER OF USERS IN EACH ARM
LONG CODE MASK
LONG CODE GENERATOR (1.2288 MCPS)
DECIMATOR
RELATIVE OFFSET CALCULATION
X_Q
Q-ARM DATA RATE =
0.6 KBPS IF N=12
1.2 KBPS IF N=24
2.4 KBPS IF N=48
4.8 KBPS IF N=96
9.6 KBPS IF N=192

FIG. 5

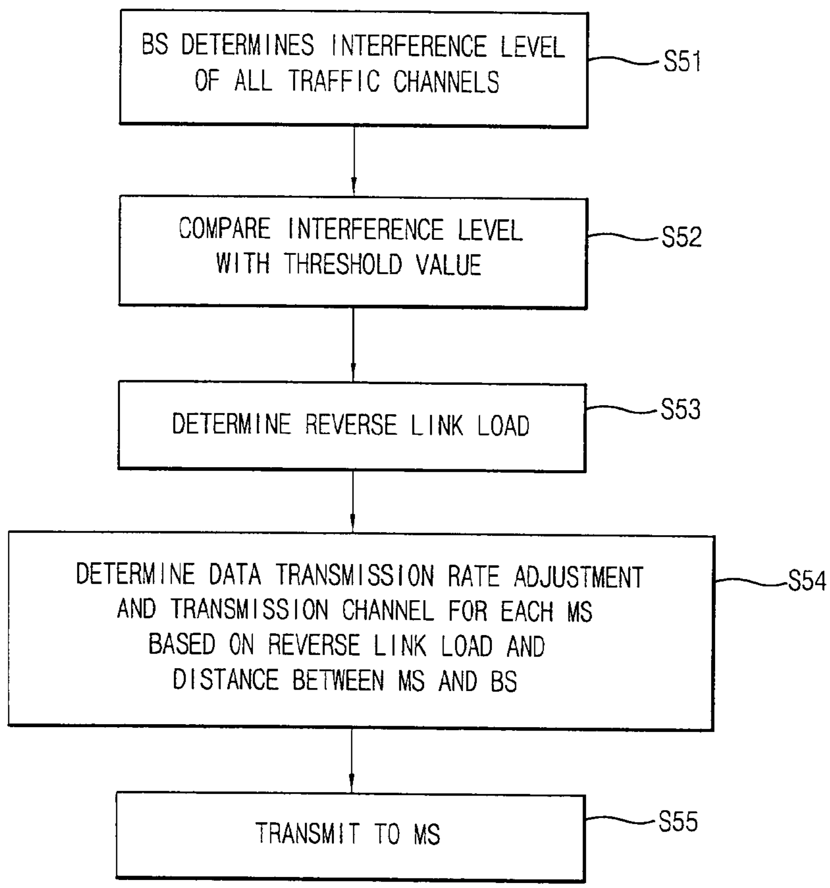

BS DETERMINES INTERFERENCE LEVEL OF ALL TRAFFIC CHANNELS
S51
COMPARE INTERFERENCE LEVEL WITH THRESHOLD VALUE
S52
DETERMINE REVERSE LINK LOAD
S53
DETERMINE DATA TRANSMISSION RATE ADJUSTMENT AND TRANSMISSION CHANNEL FOR EACH MS BASED ON REVERSE LINK LOAD AND DISTANCE BETWEEN MS AND BS
S54
TRANSMIT TO MS
S55

FIG. 6

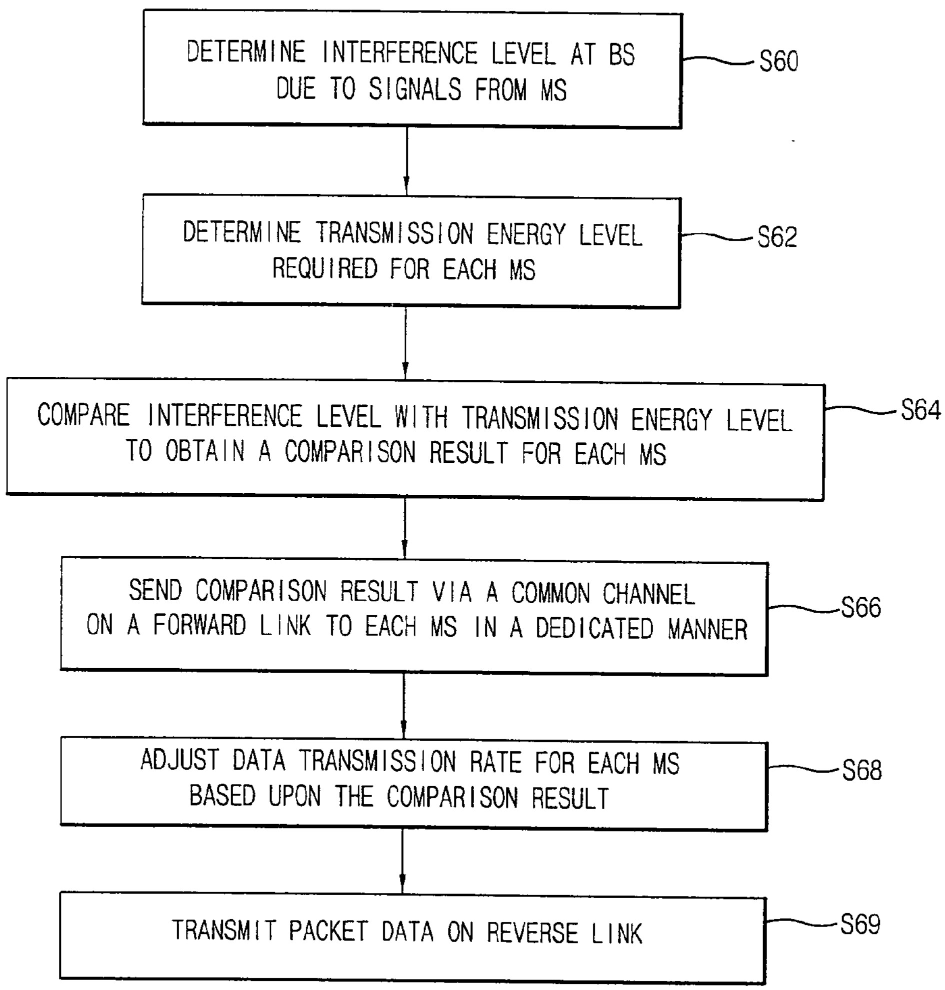

DETERMINE INTERFERENCE LEVEL AT BS DUE TO SIGNALS FROM MS
S60
DETERMINE TRANSMISSION ENERGY LEVEL REQUIRED FOR EACH MS
S62
COMPARE INTERFERENCE LEVEL WITH TRANSMISSION ENERGY LEVEL TO OBTAIN A COMPARISON RESULT FOR EACH MS
S64
SEND COMPARISON RESULT VIA A COMMON CHANNEL ON A FORWARD LINK TO EACH MS IN A DEDICATED MANNER
S66
ADJUST DATA TRANSMISSION RATE FOR EACH MS BASED UPON THE COMPARISON RESULT
S68
TRANSMIT PACKET DATA ON REVERSE LINK
S69

FIG. 7

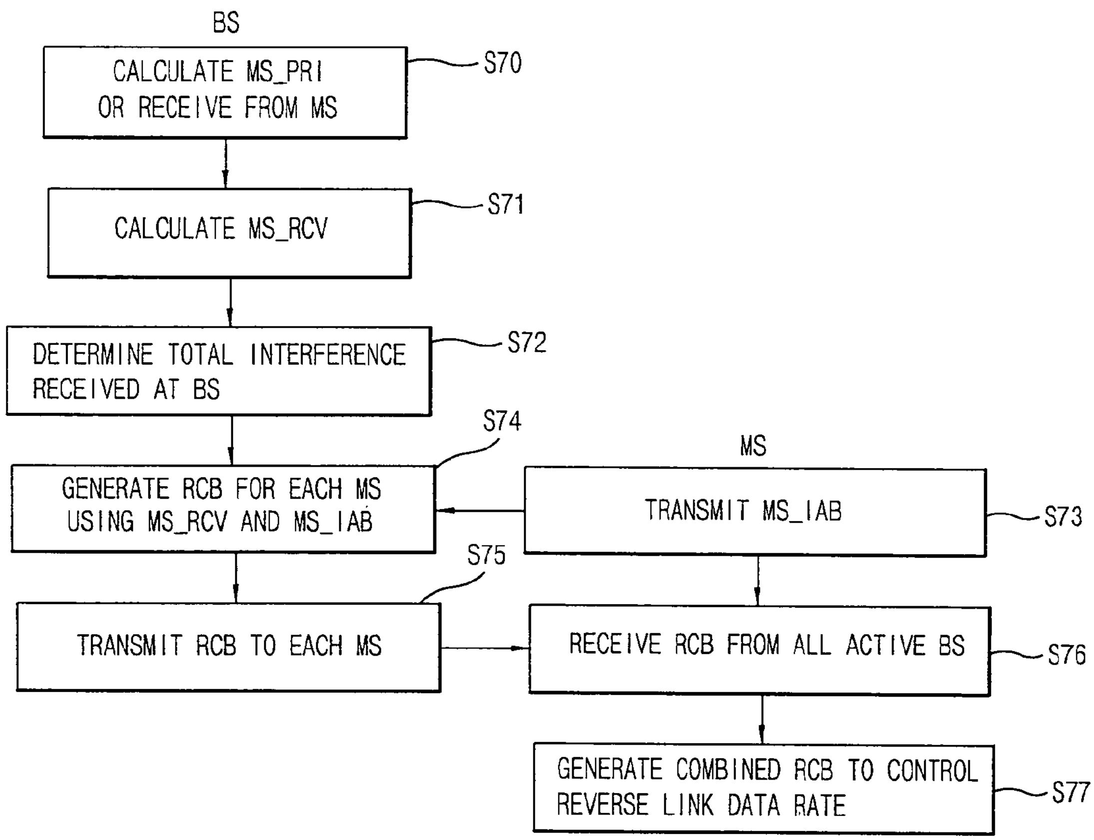

BS
CALCULATE MS_PRI OR RECEIVE FROM MS
S70
CALCULATE MS_RCV
S71
DETERMINE TOTAL INTERFERENCE RECEIVED AT BS
S72
S74
GENERATE RCB FOR EACH MS USING MS_RCV AND MS_IAB
MS
TRANSMIT MS_IAB
S73
S75
TRANSMIT RCB TO EACH MS
RECEIVE RCB FROM ALL ACTIVE BS
S76
GENERATE COMBINED RCB TO CONTROL REVERSE LINK DATA RATE
S77

FIG. 8

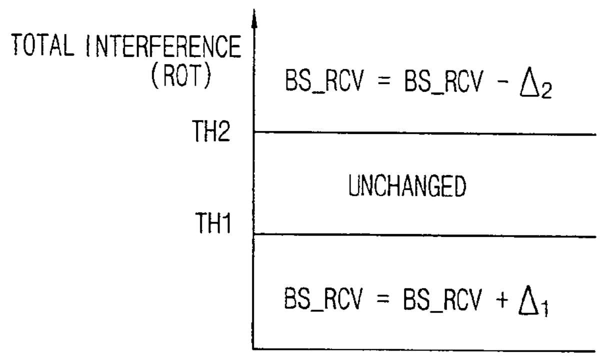

TOTAL INTERFERENCE
(ROT)
BS_RCV = BS_RCV - Δ2
TH2
UNCHANGED
TH1
BS_RCV = BS_RCV + Δ1

FIG. 9

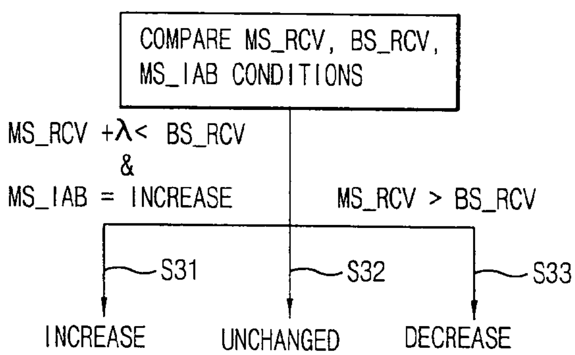
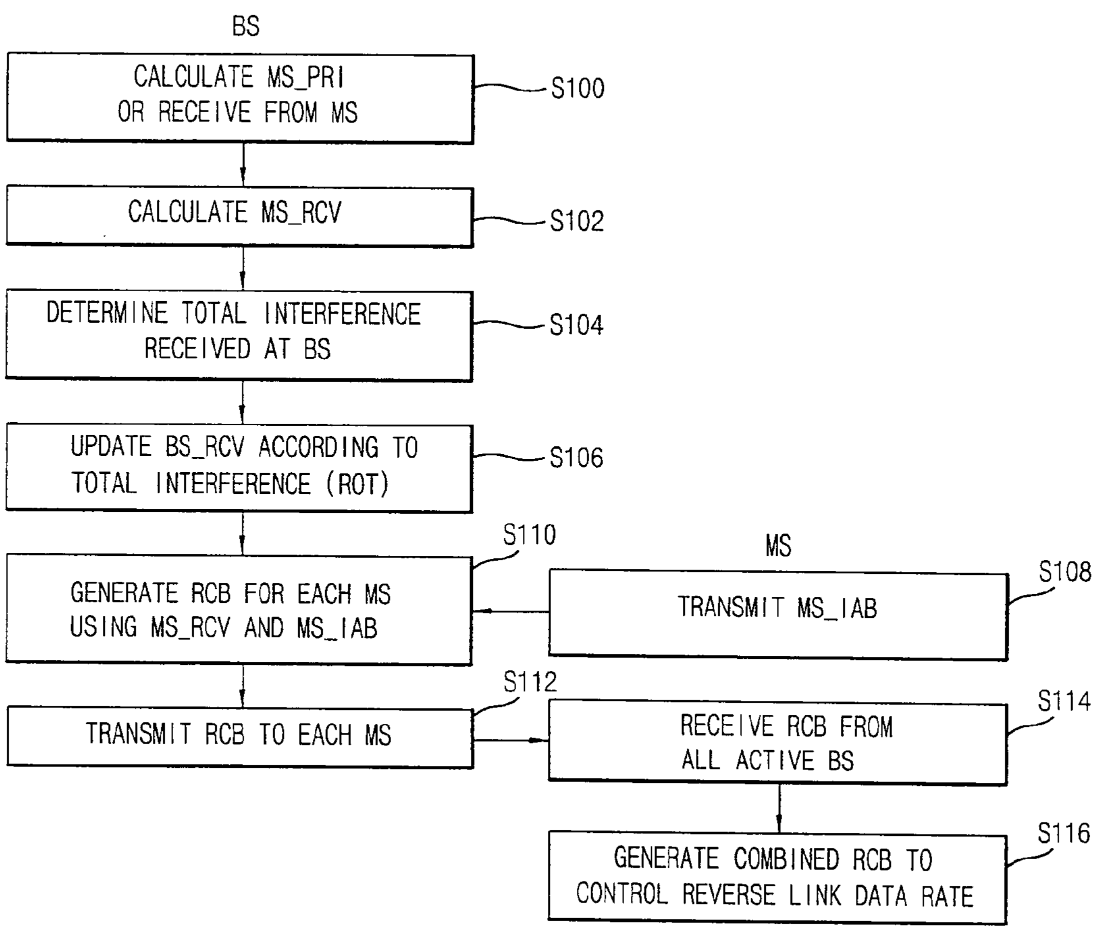

COMPARE MS_RCV, BS_RCV, MS_IAB CONDITIONS
MS_RCV +λ< BS_RCV
&
MS_IAB = INCREASE
MS_RCV > BS_RCV
S31
S32
S33
INCREASE
UNCHANGED
DECREASE

FIG. 10


BS
CALCULATE MS_PRI OR RECEIVE FROM MS
S100
CALCULATE MS_RCV
S102
DETERMINE TOTAL INTERFERENCE RECEIVED AT BS
S104
UPDATE BS_RCV ACCORDING TO TOTAL INTERFERENCE (ROT)
S106
S110
GENERATE RCB FOR EACH MS USING MS_RCV AND MS_IAB
MS
TRANSMIT MS_IAB
S108
S112
TRANSMIT RCB TO EACH MS
RECEIVE RCB FROM ALL ACTIVE BS
S114
GENERATE COMBINED RCB TO CONTROL REVERSE LINK DATA RATE
S116

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(54) Method of controlling transmission on a same radio channel of variable-rate information streams in radio communication systems, and radio communication system using this method.

(57) In a radio communication system, in particular a mobile communication system, variable-rate information flows originating from different sources (CV1, CS1; CV2, CS2) and relative to a same communication are transmitted on a same radio channel. Each mobile station (M1...Mh) and the fixed part (B1...Bn; RNC) of the system comprise a unit for the control of the variable-rate transmission, which dynamically allocates the available bits to the different streams by taking into account the needs of the sources (CV1, CS1; CV2, CS2), the conditions of the channel (6) and the system occupancy.

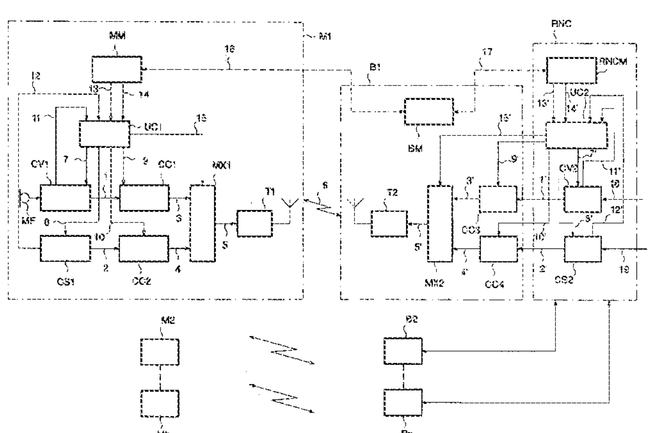

Fig. 1

EP 0 627 827 A2

The present invention relates to radio communication systems and more particularly it concerns a method of controlling transmission on the same channel of variable-rate information streams in these systems, and a system using this method.

Preferably, but not exclusively, the communication system is a mobile communication system, and the information streams are represented by coded speech signals and control signals of a speech communication on the user channel of such a system.

In the framework of research concerning future developments of mobile communications, it is being attempted to define general characteristics of systems presenting a high flexibility, so as to allow the introduction of services which today are even completely unknown or cannot be foreseen.

One example is that known as the 'Universal Mobile Telecommunications System'.

A performance which is considered as suitable is that these systems should be able to process variable-rate information streams. In fact, considering the preferred application, the two information streams (speech and control signals, meaning by the latter term both the conventional telephone signalling and the other signals, e.g. measurement results, handover commands, etc., typical of a mobile communication system) are variable-rate streams. The variability of the speech stream is due to the nature of the speech itself, the characteristics of which change during time, to the existence of pauses during a conversation, to the characteristics of the speaker, etc.

Also control signals comprise information of different nature, some of which must be transmitted periodically (e.g. results of measurements) while others (e.g. handover commands) are to be transmitted whenever necessary. Moreover, redundancy to be introduced to protect information may vary for both streams depending on the conditions of the radio channel.

Keeping this into account, access techniques to radio channels have been examined which are well suited to variable information stream processing, specially techniques of the type known as Code Division Multiple Access (CDMA). When these techniques are used, system capacity is linked to the average interference generated by active users: therefore each reduction of data transmitted at a given moment allows increasing the overall number of users served, and vice-versa, a reduction of traffic allows satisfying the requests for greater resources by certain communications.

In the case of a speech communication between a mobile station and a base station, it is possible to multiplex the two information streams, after the respective channel coding, on the same radio channel, since this solution is doubtless more efficient than the allocation of a physical channel to each stream. Considering that for each physical channel a maximum transmission rate is foreseen, which can vary depending on the system conditions, the problem arises of sharing conveniently the available bits between the two streams.

A spread spectrum communication system is already known, where two information streams at variable rates originated by two different sources (in particular speech communication traffic and communication control signals) are combined on the same physical channel. This system is described in 'Proposed EIA/TIA Wideband Spread Spectrum Standard', Qualcomm Inc., 15 May 1992, pages 6-32 to 6-42 and 7-27 to 7-83.

The known system admits four transmission rates between mobile stations and base stations, in particular 1200, 2400, 4800 and 9600 bits/s.The system can operate at anyone of the four rates when only speech signals are to be transmitted. When also control signals are to be transmitted, the system always operates at the maximum rate, keeping into account, first of all, the requirements of control signals: if these do not require all the available rate, speech signals can be transmitted too. This management system is scarcely flexible and under certain conditions it can lead to a deterioration of the speech signal quality; this deterioration could be avoided with a more sophisticated allocation criterion.

The aim of the invention is to provide a method of controlling transmission, and a system using the method, where the choice of the transmission rate is effected on the basis of a joint assessment of the needs of the individual information streams so as to keep the quality of service constant.

According to the invention, a method is therefore provided of controlling transmission on a same radio channel (in particular, a radio channel of a mobile communication system) of variable-rate information streams related to the same communication and originated by different sources, in which each stream is emitted by a source at a rate which is selected, in a given time interval, within a respective set of source rates and the stream is associated, before being sent on the channel, to a redundancy which is selected within a set of possible redundancy schemes and determines an increase of the stream rate, characterised in that, in the said interval, there are assessed the source needs in terms of the emission rate which is best suited to the stream characteristics, the channel needs in terms of the redundancy to be associated with the individual streams, and the system needs in terms of the channel rate, and each stream is allocated the emission rate and the redundancy which guarantee the attainment of a predetermined quality of the particular communication and of the service offered by the system.

The communication system utilizing the method comprises at least two stations connected via radio channels and comprising:

- sources of variable-rate information streams related to a same communication, which streams must be combined on the same radio channel, each source being able to operate, in a given time interval, at a rate chosen within a respective set of rates;
- means to introduce into each stream, in the said time interval, a redundancy chosen within a set of possible redundancy schemes, each of which causes an increase in the rate of the stream emitted by the source;
- means to combine the individual streams into a single stream to be transmitted on the channel;
- management units of the stations;

characterized in that said stations are associated with a control unit of the variable-rate streams, which unit, for each communication, receives from the sources information related to the respective needs in terms of the emission rate which is best suited to the characteristics of the respective information stream in that interval, and receives from the management units information about the needs of the channel and of the whole system during that interval, expressed in terms of redundancy to be introduced and respectively of transmission rate on the channel, and supplies the sources and the means for introducing redundancy with commands for the choice of a particular source rate and of a particular redundancy, the rates and the redundancies chosen being those which guarantee the attainment of a predetermined quality of the particular communication and of the service offered by the system.

According to a preferred embodiment of the invention, the rates and the redundancies chosen are those which meet the respective needs if the total rate resulting from the combination of the streams on the channel, expressed as the sum of the stream emission rates and the rate increments due to the redundancies, does not exceed a rate imposed by the system conditions, and otherwise each stream is allocated such an emission rate and such a redundancy as to minimize a cost of the communication, linked to the quality of the particular communication and of the service offered by the system, and given by the sum of the costs resulting from the individual needs.

Preferably, the two stations are a mobile station and a fixed part (base station and radio network control) of a mobile communication system.

The invention will be better understood with reference to the annexed drawings, where:

- Fig. 1 is a general scheme of a mobile communication system utilizing the invention;
- Fig. 2 is a block diagram of the control unit according to the invention; and
- Fig. 3 is a flow chart of the operations of the unit of Fig. 2.

In Fig. 1 the mobile communication system in which the invention is applied is schematized by a set of mobile stations M1...Mh, by a set of base stations B1...Bn, connected to the mobile stations by means of radio channels to which the stations have access according to code division techniques, and by a radio network control centre RNC.

As indicated for M1, for variable-rate speech and control signal transmission a mobile station ideally comprises:

- a speech coder CV1 which receives speech signals from microphone MF and emits on a connection 1 a coded signal at a rate r_1 generally variable frame by frame; for example CV1 can be based on analysis-by-synthesis techniques; for the purpose of the invention, CV1 constitutes the source of the respective information stream;
- a source CS1 of control signals issuing on a connection 2 a stream at a rate r_2 which is also generally variable frame by frame; in general the whole stream of control signals (hereinafter referred to also as "signaling") to be transmitted by the mobile stations to the base station will be generated locally and block CS1 schematizes the whole of the units producing this signalling;
- channel coders CC1, CC2 for speech signals and control signals, respectively, which coders receive the signals generated by CV1, CS1 and associate them with a redundancy, which in general is also variable frame by frame and results in a rate increase r_3, r_4; coders CC1, CC2 can be of any of the types used in mobile communication systems; e.g. channel coding can be based on convolutional coding.

Information streams present on outputs 3, 4 of the channel coders are combined by a multiplexer MX1 into a single stream sent through connection 5 to the CDMA transmitter T1, which forwards it on radio channel 6. MX1 and T1 incorporate all the units needed to organize the transmission according to the protocols required by the particular communication system.

Rates and redundancies r_1, r_2, r_3, r_4 to be adopted at a given time interval (e.g. a frame in a code division transmission) are communicated to blocks CV1, CS1, CC1, CC2 through connections 7-10 by a unit UC1 controlling the variable-rate transmission. UC1, which constitutes the subject matter of the invention,

communicates to MX1 also the information about total rate $r_{tot} = r_1 + r_2 + r_3 + r_4$ through connection 15. The rates are determined by UC1 keeping into account the needs of speech, signalling, channel and system.

The needs of speech and signalling can be represented by information related to the rate best suited for coding the particular speech segment or for signaling transmission in that stage. Channel conditions, which can vary both in time and depending on the position of the mobile, can be e.g. represented by information on the measured error rate, determining the protection needs of the signals and therefore the redundancy which channel coders CC1, CC2 must introduce. Finally, the system conditions, which determine the rate actually available on channel 6, depend on traffic conditions: e.g. low traffic conditions can allow a higher transmission rate for speech and therefore a better quality of the same, which can be obtained e.g. by a wide-band coding, while heavy traffic conditions can set limits to maximum data rate.

The information about the needs of CV1 and CS1 is supplied by such units to UC1 through connections 11, 12; the information related to the conditions of radio channel 6 and of the system are supplied through connections 13, 14 by a mobile station management unit MM. In general the information on the channel and on the system is not, or is not all, available to MM, which to this purpose must dialogue with the base station management unit BM, as outlined by logical connection 16.

Considering that the output quantities from UC1, i.e. the rates, are discrete quantities, it has been deemed convenient that also the input quantities should be discrete quantities, which can be represented by indices I1...I5. In particular:

- I1 ($1 \leq I1 \leq N1$) identifies which of N1 possible operating rates of the coder CV1 is best suited for speech coding in that frame; in an exemplary embodiment, seven rate values were foreseen for CV1, ranging from 400 bit/s to 16 kbit/s;
- I2 ($1 \leq I2 \leq N2$) identifies one of N2 possible transmission rates for control signals; in the said exemplary embodiment, four possible rate values were foreseen, e.g. 0, 2, 4, 8 kbit/s;
- I3, I4 ($1 \leq I3 \leq N3$ and $1 \leq I4 \leq N4$) identify one of the possible protection schemes and therefore one of the possible redundancies to be used for speech and signalling, respectively; in general, for both types of signals, the choice will be between a strong protection and a mild protection even if the same scheme uses different redundancies for the two types of signals; a single index can therefore be used to indicate the channel needs; the example considered adopted this solution with redundancies ranging from 0.6 to 11 kbits/s or from 0.6 to 15 kbits/s for speech (respectively in the case of mild or strong protection) and from 0 to 10 kbit/s or from 0 to 22 kbit/s for signalling;
- I5 ($1 \leq I5 \leq N5$) identifies one of N5 occupancy levels of the system (with level 1 corresponding to minimum occupation) and therefore one of N5 possible rates on channel 6; in the example considered, the channel rates varied between 1 kbit/s and 40 kbit/s, in steps of 1 kbit.

On the basis of this information, UC1 determines rates $r_1...r_4$ so as to satisfy entirely the rate and protection requirements of the different streams, if this is allowed by the system conditions; otherwise the rates are determined so as to minimize the total cost which must be paid to obtain a predetermined quality. Total cost will be represented by the sum of the costs linked with the individual needs. These costs in the described embodiment are digital values which give, for instance, an indication of the distortion associated with a certain rate of the coded signal (for speech) or with certain conditions of the channel or the system, or of the time required for the execution of a procedure (for control signals). These values can be determined a priori, e.g. by means of a simulation, and improved by field measurements during a stage of experimental running of system. Costs connected with the different needs must be normalized with respect to a common base. To simplify the realization, costs can be considered constant, and the described example refers to this case.

A possible example of cost minimization algorithm will be described with reference to Fig. 3.

A set of units similar to the one described is present also in the fixed part of the system, for managing communication towards the mobile. CV2, CS2, CC3, CC4, MX2, T2, UC2 correspond to the units CV1, CS1, CC1, CC2, MX1, T1, UC1 of the mobile; RNCM, BM are the management units of the radio network control unit and of the base station. References 1'...15' indicate connections corresponding to the connections 1...15 of the mobile.

As it can be seen, the devices concerned with the management of the communication towards the mobile are shared between the base station and the network control unit RNC. In particular, the devices more directly involved in the transmission aspects (channel coders, multiplexer, transmitter) are located in the base station; the speech coder, the control signal source and the control unit of the variable-rate transmission are located in the network control unit. The information about the channel and system conditions are supplied to UC2 by the network control management unit RNCM which dialogues with management unit BM of the base station in order both to obtain information about the channel and/or system conditions available only in BM, and to supply BM with the information about channel and/or system

conditions to be sent to MM. The logical connection between BM and RNCM is indicated by 17. Moreover in this case the control signals are partly generated locally and partly will arrive from the land network (not represented), from which the speech to be coded arrives to CV2. Connections with the land telecommunications network are indicated by 18, 19 for speech and control signals, respectively.

It should however be noted that the system organization shown in the Figure is a logical organization which is used to explain the location of the invention in the system and the operations performed by the invention, and it has no binding character on the real location of the units performing the functions described. In particular, logical connection 16 between BM and MM will be physically realized by means of an exchange of signalling through channel 6.

The receiving part, both in the mobile station and in the fixed part is not concerned by the invention and therefore it is not represented.

Fig. 2 shows the structure of a control unit UC, e.g. UC1. The unit comprises two groups of memories ME1-1, ME2-1, ME1-2, ME2-2...ME1-5, ME2-5 associated with each of the inputs, and a processing unit EL which executes the cost minimizing algorithm using the data read in the memories.

Memories ME1 store a parameter relevant to the stream rate at the output from the source, the channel coder and the multiplexer; the parameter is a vector (for the inputs associated with indices I1, I2, I5) or a matrix (for I3, I4). Memories ME2 store a matrix of costs. Considering that the emission rates and the redundancy schemes are fixed for a given configuration of the communication system and supposing that costs are constant, memories ME1, ME2 are read only memories.

Rate vectors $\overline{R1} = [r_1(1), r_1(2)...r_1(N1)]$, $\overline{R2} = [r_2(1)...r_2(N2)]$ and $\overline{R5} = [r_5(1)...r_5(N5)]$ are vectors with N1, N2 or respectively N5 components, corresponding each to one of the possible operation rates of CV1 and CS1 or one of the N5 transmission rates on channel 6. The components are ordered according to increasing values from the first to the N1-th or N2-th for $\overline{R1}$, $\overline{R2}$, and in a decreasing order from $r_5(1)$ to $r_5(N5)$ for $\overline{R5}$. The memories are addressed at each frame by I1, I2, I5 and supply EL, through connections 21, 22, 25, with the vector component read in each of them.

Cost matrices

$$\overline{\overline{C1}} = \begin{matrix} c_1(1,1), \ c_1(1,2) \ ... \ c_1(1,N1) \\ \ldots\ldots\ldots\ldots\ldots \\ c_1(N1,1) \ldots\ldots \ c_1(N1,N1) \end{matrix} \qquad \overline{\overline{C2}} = \begin{matrix} c_2(1,1), \ c_2(1,2) \ ... \ c_2(1,N2) \\ \ldots\ldots\ldots\ldots\ldots \\ c_2(N1,1) \ldots\ldots \ c_2(N2,N2) \end{matrix}$$

stored in ME-1, ME-2 are addressed by rows by index I1 or respectively I2 and by columns by an index i, or respectively j, generated during the communication cost minimizing algorithm. Indices i, j can take values varying from I1 (I2) to 1, including the extreme values. Indices i, j are supplied by EL through connections 41, 42. The datum read is supplied to EL through connections 31, 32. In each row the costs decrease as the column index increases.

Costs c_1 can for example express a measure of the perceptual distortion associated with a particular combination requested rate - allocable rate. Costs c_2 can be the expression of the quality of service represented e.g. as the time for the execution of a procedure and therefore as the probability that the procedure itself could be completed in a preset time. In practice, since i, j can never exceed I1, I2, the matrices are triangular matrices, where only the values below the diagonal differ from 0; the costs on the diagonal can be allotted the value 0, where 'cost 0' means that the system is able to supply exactly the requested rate. The same convention will be adopted for the other cost matrices.

Cost matrix

$$\overline{\overline{C5}} = \begin{matrix} c_5(1,1) \; \ldots\ldots \; c_5(1,N5) \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ c_5(N5,1) \; \ldots\ldots c_5(N5,N5) \end{matrix}$$

stored in ME2-5 is addressed by index I5 for the rows and by an index Ir, associated with the total rate r_{tot} and generated during the cost minimization algorithm, for the columns. Index Ir is present on a connection 45.

It is to be noted that, when r_{tot} lies between two consecutive values of r_5, index Ir is associated with the higher value: i.e., considering that the rates in $\overline{R5}$ are decreasing, $\overline{R5}(Ir+1) < r_{tot} \leq \overline{R5}(Ir)$. Costs c_5 decrease along the rows.

In matrix

$$\overline{\overline{C5}}$$

costs c_5 (p,q) with p>q correspond to system rates greater than total rate and therefore can be considered as negative costs; the opposite for p<q. The datum read in

$$\overline{\overline{C5}}$$

is supplied to E1 through connection 35.

The third and fourth inputs are associated with memories ME1-3, ME1-4 and ME2-3, ME2-4 storing respective rate matrices

$$\overline{\overline{R3}}, \quad \overline{\overline{R4}}$$

and cost matrices

$$\overline{\overline{C3}}, \; \overline{\overline{C4}}.$$

The two rate matrices

$$\overline{\overline{R3}} = \begin{matrix} r_3(1,1) \; \ldots. \; r_3(1,N3) \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ r_3(N1,1) \; \ldots. \; r_3(N1,N3) \end{matrix} \qquad \overline{\overline{R4}} = \begin{matrix} r_4(1,1) \; \ldots \; r_4(1,N4) \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ r_4(N2,1) \ldots r_4(N2,N4) \end{matrix}$$

contain N1 or respectively N2 rows corresponding to the N1 or N2 source rates, and N3 or respectively N4 columns (with N3 = N4 in the example considered) whose number is equal to the number of foreseen channel coding schemes. Rate values in the rows of the two matrices increase as the column index increases. Reading pointers in the two matrices are respectively I1, I2 for the rows and I3 for the columns. The datum read is presented on connections 23, 24. The two matrices are constant.

Cost matrices

$$\overline{\overline{C3}} = \begin{matrix} c_3(1,1) \ldots c_3(1,N3) \\ \ldots\ldots\ldots\ldots\ldots \\ c_3(N3,1) \ldots c_3(N3,N3) \end{matrix} \qquad \overline{\overline{C4}} = \begin{matrix} c_4(1,1) \ldots c_4(1,N4) \\ \ldots\ldots\ldots\ldots\ldots \\ c_4(N4,1) \ldots c_4(N4,N4) \end{matrix}$$

stored in ME2-3, ME2-4 are totally similar to matrices

$$\overline{\overline{C1}},\ \overline{\overline{C2}}.$$

Costs can represent a distortion introduced by the channel on the respective signal: for the speech this will be a perceptual distortion, as is the case of

$$\overline{\overline{C1}},$$

while for control signals it will be a probability that the signal could not be interpreted correctly.

The two matrices are addressed by rows by I3, while columns will be addressed by an index k, supplied by E1 through connection 43, which is generated during the cost minimization algorithm and which can vary from I3 to 1. The data read are supplied to E1 through connections 33, 34.

Figure 3 contains the flow chart of the algorithm. At each frame, the rate vector/matrix components addressed by indices I1...I5 and the values of the indices are loaded in EL (step 101). Said components are indicated as r_m (min) where m = 1,2,3,4. The corresponding total rate

$$r_{tot}(min) = \sum_{m=1}^{4} r_m(min)$$

is then determined and compared with rate r_5 permitted by the system (steps 102, 103). If r_{tot}(min) does not exceed r_5, the four rates requested are accepted and the relevant commands are emitted for blocks CV1, CS1, CC1, CC2, MX1 (CV2...MX2) (step 104).

If the total rate required exceeds system rate r_5, it is necessary to pass on to cost evaluation. Total cost of the request is initialized to a value Cmin = ∞ (step 105) and every possible rate combination, equal to or lower than those indicated by indices I1 - I4, is tested (steps 106-109). The combinations different from the initial one are obtained by diminishing the individual indices by 1 unit, independently from one another. Indices i, j, k represent the values assigned to I1, I2, I3 at a given step of the test. For each combination of i, j, k, the total rate is calculated again (step 110) and is compared now with the maximum rate admissible on the channel (step 111). If the total rate is higher than maximum rate, the only possibility is to try a combination of lower values, otherwise the cost of the combination under test will be assessed. Comparison with maximum rate and not with system rate r_5 means that the possibility is also envisaged of allocating the communication a total rate which is higher than the system rate, by paying the respective price, represented by cost c_5(I5,Ir).

For cost assessment, it is necessary to determine index Ir (step 112) and to calculate total cost Ctot, as the sum of the costs addressed in the individual matrices

$$\overline{\overline{C1}} \ldots \overline{\overline{C5}}$$

(step 113). This cost is compared with value Cmin (∞ if the initial combination is being assessed) (step 114) and whenever a total cost is lower than the one stored in memory this value is updated. Also the corresponding values $r_1 ... r_4$, r_{tot} are stored. At the end of the test on all the combinations of indices i, j, k, unit EL will supply values $r_1 ... r_4$, r_{tot} determined.

It is clear that trying all possible combinations of values of i, j, k can be effected so long as indices I1...I5 have a limited number of values, as in the example given. Under these conditions, control unit UC2 could also simultaneously manage several communications. If the number of combinations is too high, dynamic programming techniques, tree selection techniques and so on, can be used, which allow discarding beforehand a number of combinations.

It is clear that what described has been given only by way of non limiting example, and that variations and modifications are possible without going out of the scope of the invention.

For example, even if matrices

$$\overline{\overline{C1}}...\overline{\overline{C5}}$$

have been assumed to be constant for all frames, it is possible to update the values periodically. As an alternative to storage as matrices, the costs related to source and channel conditions could be organized into vectors, corresponding to the first column of the respective matrices; these vectors would vary on a frame by frame basis. Moreover, the cost vector relative to the second input would also be a function of the choice made in the preceding frames, since each choice influences the probability that the procedure can be brought to successful conclusion within the time set.

Furthermore, the invention can be applied for services other than speech transmission, such as variable-rate data transmission, in which the two streams would be represented by the data and by the signalling, or in systems employing access techniques different from CDMA but always in connection with variable-rate transmissions, e.g. PRMA (Packet Reservation Multiple Access) or ATM (Asynchronous Transfer Mode) techniques. Moreover, even if the invention has been disclosed in connection with a mobile communication system, it can be also applied to other radio communication systems comprising at least two stations connected via radio channels, in particular satellite communication systems.

Claims

1. Method of controlling transmission, on a same radio channel, of variable-rate information streams relative to the same communication and originated from different sources, in which each stream is emitted by a source (CV1, CS1; CV2, CS2) at a rate (r_1, r_2) which, in a given time interval, is chosen within a respective set of source rates and the stream is associated, before being sent on the channel (6), with a redundancy which is chosen within a set of possible redundancy schemes and which determines an increment (r_3, r_4) in the stream rate, characterized in that during the said interval there are assessed the source needs in terms of the emission rate which is best suited to the stream characteristics, the channel needs in terms of the redundancy to be associated with the individual streams, and the system needs in terms of channel rate, and each stream is allocated the emission rate and the redundancy which guarantee a predetermined quality of the particular communication and of the service offered by the system.

2. Method according to Claim 1, characterized in that each stream is allocated the emission rate and the redundancy which meet the respective needs if the total rate (r_{tot}) resulting from the combination of the streams on the channel, expressed as the sum of the stream emission rates and the rate increments due to the redundancies, does not exceed a rate (r_5) imposed by the system conditions, and otherwise each stream is allocated such an emission rate and such a redundancy as to minimize a cost of the communication, linked to the quality of the particular communication and of the service offered by the system, and given by the sum of the costs resulting from the individual needs.

3. Method according to Claim 1 or 2, characterized in that the radio channel is the communication channel between a mobile station and a base station of a mobile communication system, and the assessment of said needs is performed separately in the mobile station and in a fixed part of the system, respectively for the direction from the mobile station towards the fixed part and for the opposite direction.

4. Method according to any of Claims 1 to 3, characterized in that, for each direction of the communication, the information on said needs are represented by indices (I1...I5), linked to one of the possible source rates of each stream, to one of the possible redundancy schemes and to one of the possible channel rates.

5. Method according to Claim 4, characterized in that said indices constitute reading addresses for accessing stored information on the emission and channel transmission rates and on the rate increments caused by the redundancies, as well as on the costs associated with the rates and redundancies actually allocable.

6. Method according to Claim 5, characterized in that the information on the channel needs is represented by a single index for all information streams.

7. Method according to any of Claims 4 to 6, characterized in that the stored information relative to the source rates and to the channel rates consists of vectors with as many components as there are possible rate values, and the information on the rate increments caused by the redundancies is represented by matrices in which each component is associated with a combination of source/redundancy rates.

8. Method according to any of Claims 4 to 7, characterized in that the stored information relative to costs is in the form of digital values, normalized with respect to a common base and organized into matrices in which each component is associated with a combination of rates/ redundancies required and rates/redundancies allocable.

9. Method according to Claim 8, characterized in that said cost matrices are constant matrices.

10. Method according to any of Claims 4 to 7, characterized in that the information stored relative to costs related to the source and channel needs is in the form of digital values organized into vectors, updated at every time interval.

11. Method according to any preceding claim, characterized in that the information streams are digitally coded speech signals and control signals of a speech communication .

12. Method according to any of Claims 1 to 10, characterized in that the information streams are data and control signals of a variable-rate data transmission.

13. Method according to any preceding claim, characterized in that the mobile communication system is a system in which channel access occurs according to code division techniques and the transmission period on the channel is divided into frames, and in that the determination of the rate and of the redundancy to be allocated to the individual streams is made at each frame.

14. Method according to any of claims 1 to 12, characterized in that the communication system is a system in which channel access for variable-rate transmissions occurs according to time division technique.

15. Communication system including at least two stations (M1...Mh; RNC; B1...Bn) connected via radio channels and including:
   - sources (CV1, CS1; CV2, CS2) of variable-rate information streams relative to a single communication that must be combined on a single radio channel (6), each source being able to operate, in a given time interval, with a rate (r_1, r_2) chosen within a respective set of rates;
   - means (CC1, CC2; CC3, CC4) to introduce into each stream, in said time interval, a redundancy chosen from a set of possible redundancy schemes, each of which causes an increment (r_3, r_4) in the rate of the stream emitted by the source;
   - means (MX1, MX2) to combine the individual streams into a single stream to be transmitted on the channel (6);
   - management units (MM, BM, RNCM) of the stations;

   characterized in that said stations are associated with a variable-rate stream control unit (UC1, UC2) which, for each communication: receives from the sources (CV1, CS1; CV2, CS2) information on the source needs in terms of the emission rate which is best suited to the characteristics of the respective

information stream in that interval; receives from the management units (MM, RNCM) information on the needs of the channel (6) and of the entire system in that interval, expressed in terms of redundancy and respectively of transmission rate on the channel; determines a particular source rate and a particular redundancy for each stream and provides the sources (CV1, CS1; CV2, CS2) and the means (CC1, CC2; CC3, CC4) for redundancy introduction with commands for the choice of that particular source rate and redundancy, the rates and redundancies chosen being those which guarantee the attainment of a predetermined quality of the particular communication and of the service offered by the system.

16. Communication system according to Claim 15, characterized in that the rates and redundancies chosen are those which satisfy the source and channel needs in that interval, if the total rate (r_{tot}) of the stream resulting from the combination, expressed as the sum of the emission rates of the streams and the rate increments caused by the redundancies, does not exceed a rate (r_S) determined by the system conditions, while otherwise the rates and redundancies are chosen so as to minimize a total cost of the communication, linked to the quality of the particular communication and of the service offered by the system, and given by the sum of the costs resulting from the individual needs.

17. Communication system according to Claim 15 or 16, characterized in that each control unit (UC1; UC2) includes:
- a first group of memories (ME1-1...ME1-5), which store information relative to the possible rates of the streams emitted by the sources, to the combinations of each of these rates with each of the redundancies foreseen for the respective stream, and to the possible rates on the channel, and which are addressed respectively by the information on the needs of the sources (CV1, CS1; CV2, CS2), of the channel (6) and of the system supplied by the sources (CV1, CS1; CV1, CS2) and the management units (MM, RNCM), respectively;
- a second group of memories (ME2-1...ME2-5), which store information on the costs associated with the possible choices of rates of the streams flowing from the sources, of the redundancy required by the channel conditions and of the rate on the channel (6), and are addressed in reading at least by the information provided by the sources (CV1, CS1; CV2, CS2) and by the management units (MM, RNCM);
- a processing unit (EL), which receives from the sources (CV1, CS1; CV2, CS2) and from the management units (MM, RNCM) information on the source, channel and system needs, and from the first and second group of memories (ME1-1...ME1-5, ME2-1...ME2-5) information on the rates, redundancies and costs, and provides the sources (CV1, CS1; CV2, CS2) and the means (CC1...CC4) of redundancy introduction with commands for the choice of the emission rate and of the redundancy.

18. Communication system according to any of Claims 15 to 17, characterized in that the sources (CV1, CS1; CV2, CS2) and the management units (MM, RNCM) provide the information on the source, channel and system needs in the form of indices (I1...I5) which constitute reading addresses or parts of the reading addresses in said memories (ME1-1...ME2-5).

19. Communication system according to Claim 17 or 18, characterized in that, in the first group of memories (ME1-1...ME1-5), the memories (ME1-1, ME1-2, ME1-5) for the information on the source and channel needs store rate values organized into vectors, each having as many components as there are possible values for the source and channel rates, and the memories (ME1-3, ME1-4) for information on the channel needs store rate values organized into matrices in which each row is associated with one of the rate values of the respective source, and each column with one of the possible increments caused by the redundancy.

20. Communication system according to any of Claims 17 to 19, characterized in that the memories of the second group (ME2-1...ME2-5) store numerical cost values organized into matrices, and each memory location is addressed jointly by one of the said indices (I1...I5) and by a further index, generated by said processing unit (EL) during the determination of the rates and of the redundancies and associated with a rate or a redundancy that can be actually allocated to the individual streams emitted by the source or respectively to the total rate of the stream resulting from the combination.

21. Communication system according to Claim 20 characterized in that said cost matrices are constant matrices.

22. Communication system according to any of Claims 17 to 19 characterized in that the memories of the second group (ME2-1...ME2-4) storing costs related to the source and channel needs store numerical values organized into vectors, updated at each time interval.

23. Communication system according to any of Claims 15 to 22, characterized in that the information streams are speech signals coded in digital form and control signals of a speech communication.

24. Communication system according to any of Claims 15 to 22, characterized in that the information streams are data and control signals of a variable-rate data transmission.

25. Communication system according to any of Claims 15 to 24, characterized in that the communication system is a mobile communication system comprising a plurality of mobile stations (M1...Mh) and a fixed part (RNC; B1...Bn), consisting of base stations (B1...Bn) and of radio network control units (RNC), and the unit (UC1, UC2) controlling the variable rate streams is provided in each mobile station (M1...Mh) and in the fixed part (RNC; B1...Bn).

26. Communication system according to Claim 25, characterized in that the mobile communication system is a system in which channel access occurs through code division techniques.

27. Communication system according to Claim 25, characterized in that the mobile communication system is a system in which channel access for a variable-rate transmission occurs through time division techniques.

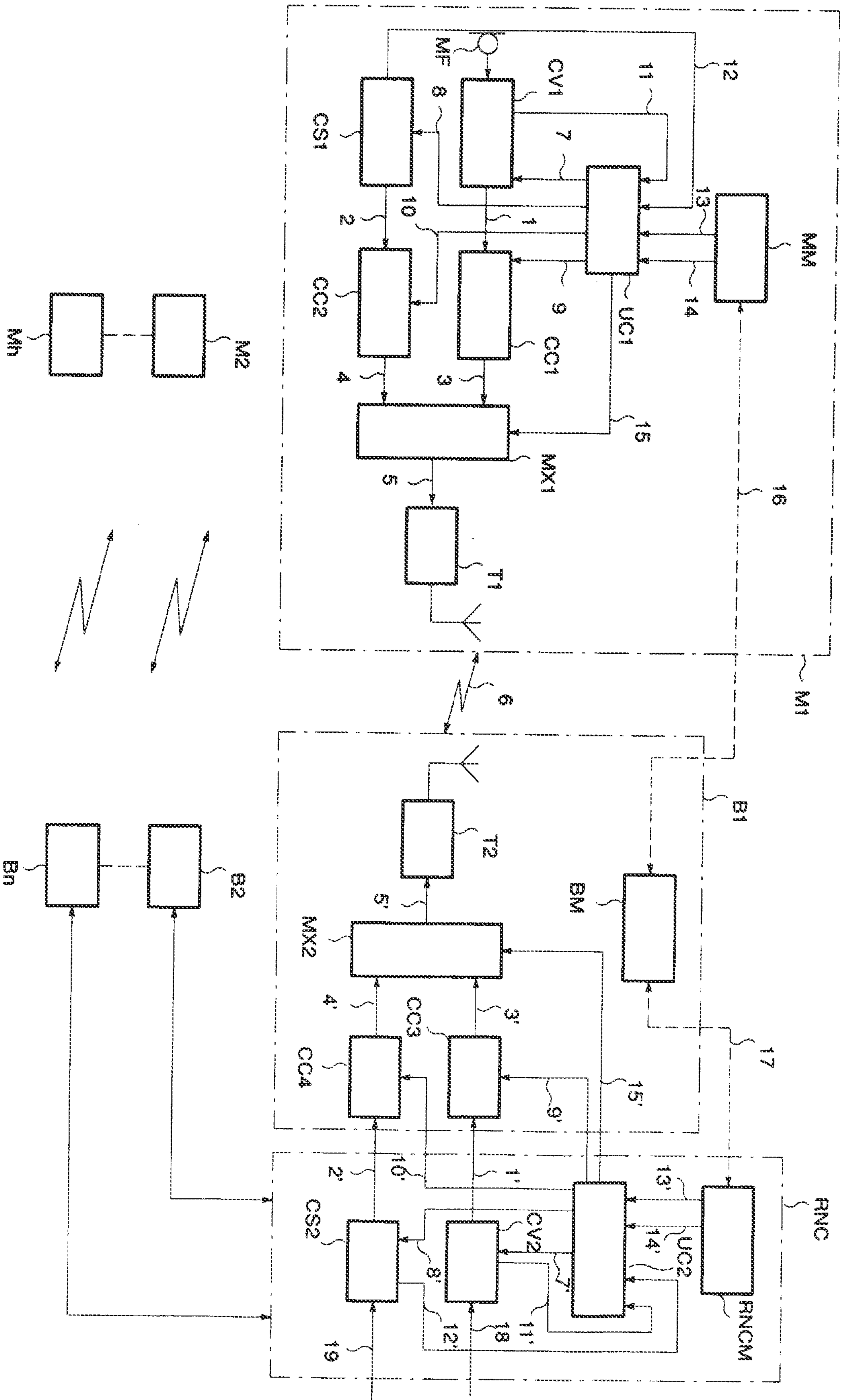
M1
MM
UC1
CV1
CS1
CC1
CC2
MX1
T1
MF
M2
Mh
B1
BM
T2
MX2
CC3
CC4
RNC
RNCM
UC2
CV2
CS2
B2
Bn

Fig. 1

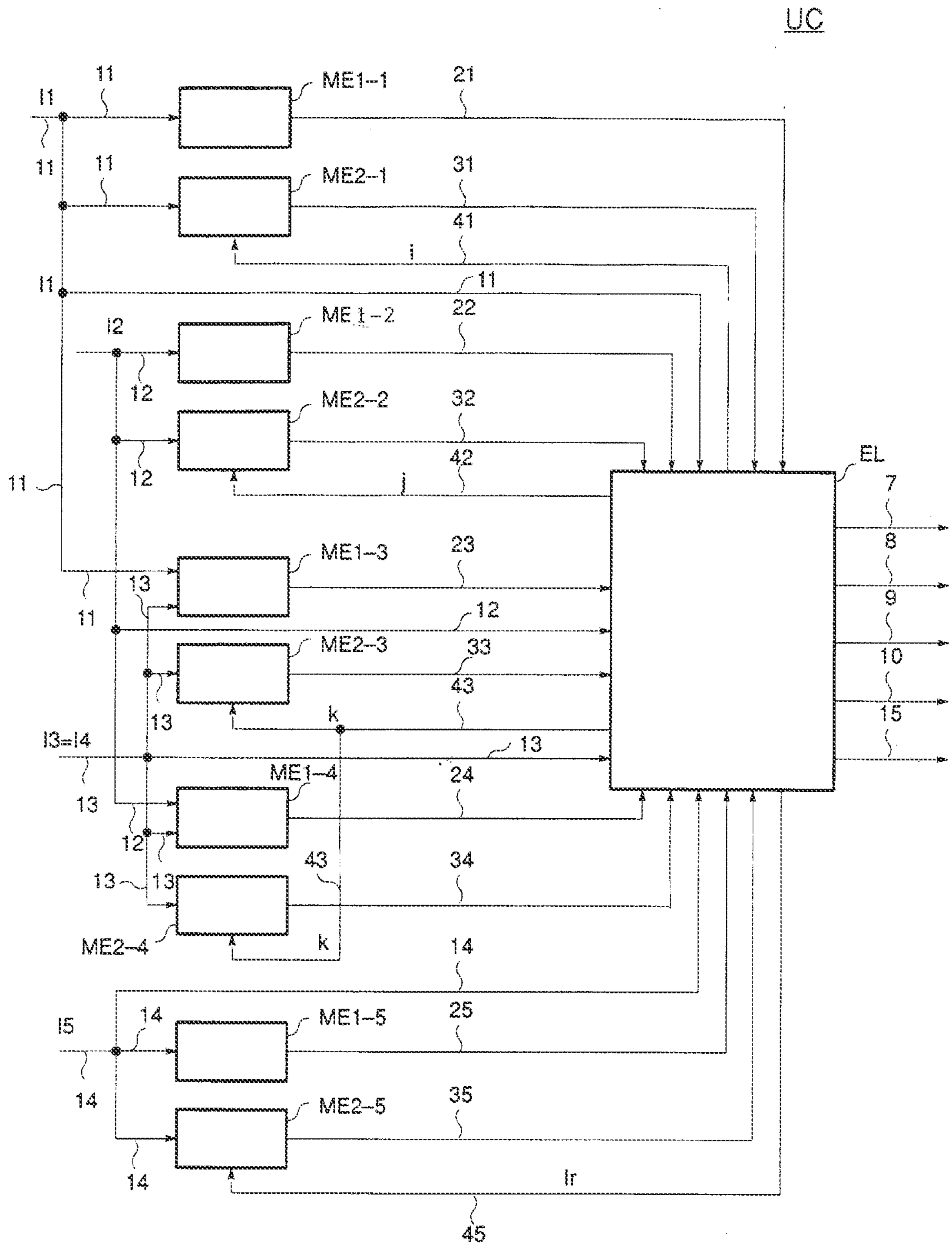
UC
I1
11
ME1–1
21
ME2–1
31
41
i
ME1–2
22
I2
12
ME2–2
32
42
j
EL
7
8
9
10
15
ME1–3
23
13
ME2–3
33
43
k
I3=I4
24
ME1–4
34
ME2–4
14
I5
ME1–5
25
ME2–5
35
Ir
45

Fig. 2

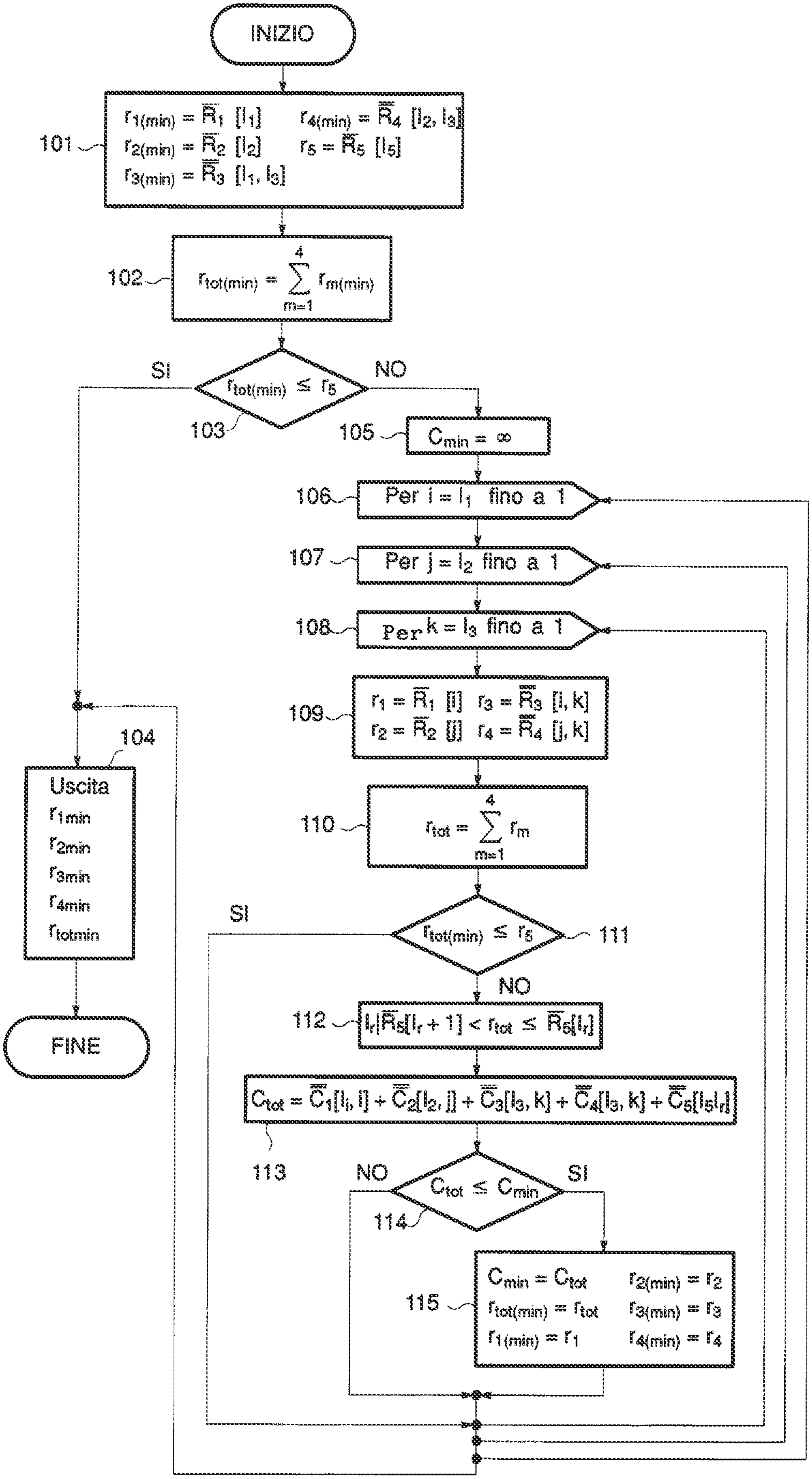
INIZIO
101
$r_{1(min)} = \overline{R}_1\ [l_1]$
$r_{2(min)} = \overline{R}_2\ [l_2]$
$r_{3(min)} = \overline{\overline{R}}_3\ [l_1, l_3]$
$r_{4(min)} = \overline{\overline{R}}_4\ [l_2, l_3]$
$r_5 = \overline{R}_5\ [l_5]$
102
$r_{tot(min)} = \sum_{m=1}^{4} r_{m(min)}$
SI
NO
$r_{tot(min)} \leq r_5$
103
105
$C_{min} = \infty$
106
Per $i = l_1$ fino a 1
107
Per $j = l_2$ fino a 1
108
Per $k = l_3$ fino a 1
109
$r_1 = \overline{R}_1\ [i]$
$r_3 = \overline{\overline{R}}_3\ [i, k]$
$r_2 = \overline{R}_2\ [j]$
$r_4 = \overline{\overline{R}}_4\ [j, k]$
110
$r_{tot} = \sum_{m=1}^{4} r_m$
104
Uscita
r_{1min}
r_{2min}
r_{3min}
r_{4min}
r_{totmin}
FINE
SI
$r_{tot(min)} \leq r_5$
111
NO
112
$l_r | \overline{R}_5[l_r + 1] < r_{tot} \leq \overline{R}_5[l_r]$
$C_{tot} = \overline{\overline{C}}_1[l_i, i] + \overline{\overline{C}}_2[l_2, j] + \overline{\overline{C}}_3[l_3, k] + \overline{\overline{C}}_4[l_3, k] + \overline{\overline{C}}_5[l_5 l_r]$
113
NO
SI
$C_{tot} \leq C_{min}$
114
115
$C_{min} = C_{tot}$
$r_{tot(min)} = r_{tot}$
$r_{1(min)} = r_1$
$r_{2(min)} = r_2$
$r_{3(min)} = r_3$
$r_{4(min)} = r_4$

Fig. 3

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(54) **Method to control uplink transmissions in a wireless communication system**

(57) Efficient data communication in wireless communication system is provided by using centralized control of data communications, such as packet switched services, over the uplink channel (mobile station (MS) to base station (BS)). A multiple access protocol is used where packet data mobile stations make requests for uplink channel resources. The request messages transmitted by the MSs inform the BS of service parameters. Examples of such service parameters are available transmit power at the MS, the amount of data to transmit and Quality of Service (QoS). The BS then processes the received request messages and performs interference management calculations to determine the portion of the BS's receive power budget that can be allocated to the data user requesting service. These calculations are used to control the amount of interference seen at the base station, to assign a data rate to the user and to aid scheduling algorithms in computing service order priorities. Any scheduling algorithm may be used; for example, scheduling may be based on the amount of data to be transmitted, the age of the data or the service priority associated with the mobile station. The interference control is used to prevent the occurrence of catastrophic levels of interference while maximizing the utilization of resources on the uplink.

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Description

Field of the Invention

[0001] The present invention relates to communications; more specifically, wireless communications.

Description of the Related Art

[0002] Previously, resource management and channel allocation on the uplink or reverse link (RL) has been treated primarily as a "distributed control" problem. In other words, a Base Station (BS) did not control the operations by assigning service order priorities. However, the BS did supervise access to the reverse link and monitor operations via slow or fast power control. For example, in CDMA 2000-1x systems, each mobile requested a reverse link channel at a specific rate. The BS monitored the interference patterns and determined whether to admit the user or not. Once the user was admitted at a chosen rate, the BS monitored the subsequent transmissions via fast power control. Another example of reverse link access and control can be found in 1xEV-DO systems. In these systems, every mobile began to transmit autonomously beginning with the lowest rate in the rate set. At every subsequent transmission, each mobile autonomously doubled its data rate. The base station continued to monitor the channel via power control. If the aggregate received power at the BS or the interference to each user exceeds a predefined threshold, the BS ordered all mobiles to reduce their data rates. Due to the autonomous nature of the transactions, this resulted in an inefficient data communications on the uplink between mobile stations and base stations.

Summary of the Invention

[0003] One embodiment of the present invention provides efficient data communication in wireless communication systems by providing centralized control of data communications, such as packet switched services, over the uplink channel (mobile station (MS) to base station (BS)). A multiple access protocol is used where packet data mobile stations make requests for uplink channel resources. The request messages transmitted by the MSs inform the BS of service parameters. Examples of such service parameters are available transmit power at the MS, the amount of data to transmit and Quality of Service (QoS). The BS then processes the received request messages and performs interference management calculations to determine the portion of the BS's receive power budget that can be allocated to the data user requesting service. These calculations are used to control the amount of interference seen at the base station, to assign a data rate to the user and to aid scheduling algorithms in computing service order priorities. Any scheduling algorithm may be used; for example, scheduling may be based on the amount of data to be transmitted, the age of the data or the service priority associated with the mobile station. The interference control is used to prevent the occurrence of catastrophic levels of interference while maximizing the utilization of resources on the uplink.

[0004] This method is useful in wireless communication systems such as Code Division Multiple Access (CDMA) systems, which serve a mixture of traffic classes; for example, voice services and data services. The method is particularly useful with respect to the packet data component of the overall traffic and serves to efficiently utilize the uplink channel while striking a balance between minimizing aggregate channel interference and improving user level quality of service (QoS).

Brief Description of the Drawing

[0005] FIG. 1 illustrates a receive power or interference power budget at a base station.

Detailed Description

[0006] The centralized protocol and interference management scheme strikes a balance between network throughput and user level QoS. This is achieved via a combination of fast rate adaptation (and some power control if necessary), and centralized scheduling at the BS. In addition to enabling fast scheduling, this mechanism enables the use of advanced techniques such as hybrid ARQ and various flavors of incremental redundancy. These techniques are applicable when fast rate adaption is used (as opposed to conventional power control) and are aimed at improving network and user performance.

[0007] The multiple access protocol used is a modification of the DQRUMA protocol described in "Distributed-Queueing Request Update Multiple Access (DQRUMA) for Wireless Packet (ATM) Networks," by M. J. Karol, Z. Liu, and K. Y. Eng, in Proc. Intl. Conference on Communications, pp. 1224-1231, June 1995, and is optimized for packet data systems using CDMA in the reverse link. The interference management scheme has several options. One option relates to relatively slow scheduling by averaging across various measurements (in the reverse link) in order to optimize purely

for user level satisfaction. The averaging eliminates or reduces any channel variations and renders the effective channel somewhat static. Another option relates to fast scheduling by tracking and exploiting channel variations to improve throughput and reduce interference. A combination of these options can also be performed. Moreover, each component is applicable independent of the other components. For example, the protocol is applicable with any interference management scheme and any scheduling scheme.

[0008] In CDMA systems, the reverse link consists of users transmitting individually with little or no synchrony between users. Data from a user can be classified into three broad categories: control and signaling information (such as power control bits, channel quality information, etc.), protocol information (for example, access reservation requests), and actual data traffic relevant to the service. These (and possibly more) classes of data, are usually spread using separate Walsh codes. For example, the first Walsh code may be designated for signaling, the second for protocol information, and the third and fourth for voice and data services, respectively. These spread messages are then combined and further spread using the user-specific long code. The initial Walsh spreading is done to enable the BS to differentiate between the categories of data, and the subsequent long code spreading is done to differentiate between users.

[0009] For instance, Walsh code 2 could be used for making requests for channels to transmit in the uplink. If the reservation is accepted and a reverse link transmission is scheduled, then data is sent along Walsh code 4. During a given transmission, any combination of these Walsh codes could be used thereby enabling the mobiles to send control information, as well as make reservations, along with traffic channel data (all of them simultaneously). The set of Walsh codes that will be used in any given system will be fixed across users. The user long codes will be generated as in current CDMA systems such as IS-95, IS-2000, or UTRAN. These long codes are applied on top of the Walsh coded streams and help distinguish one user's signal from another. Due to the use of user-specific long codes, the same set of Walsh codes can be used by every user to spread different data streams.

[0010] An example of the control channels (including bit budgets) required is outlined in the following. These channels can be sent over separate Walsh codes or can be time-multiplexed onto a single code. This structure could be used to implement the protocol described in the following section.

The Reverse Pilot Reference Channel

[0011] This channel carries the transmit power used for the mobile station's Reverse Pilot Channel. It consists of a 6-bit field transmitted once every 10 ms, and aids the base station in making scheduling decisions.

The Reverse Request/Update Channel

[0012] This channel is used by the mobile station to make new or updated scheduling requests to the base station. This 6-bit field indicates the size of traffic data to be transmitted (expressed as number of 768-bit packets), and is transmitted once every 10 ms.

The Reverse Rate Indicator Channel

[0013] This channel is used by the mobile station to indicate the data rate on the Reverse Packet Data Channel. This 4-bit field is sent in a single slot, every packet. If the base station and the mobile station are not implicitly aware of the information block size to be used on the data traffic channel, then additional bits can be added to carry this information.

The Reverse Hybrid ARQ Control Channel

[0014] This channel carries control information to aid in the Hybrid ARQ operation at the base station receiver. Hybrid ARQ is well known and is disclosed in publications as "Error Control Coding: Fundamentals and Applications," by S. Lin and D. J. Costello, Prentice Hall, 1983, pages 477-481 and "Error Control Systems for Digital Communication and Storage, by S. B. Wicker, Prentice Hall, 1995, pages 409-422.

The Forward Schedule Grant Channel

[0015] This channel communicates a reverse link transmit start time to one or more mobiles. This channel may be a common channel or overhead channel that identifies a particular mobile for message reception, or it may be a mobile specific channel communicating a message such as a one bit message. Messages on this channel may also be used to communicate reverse link data rate and/or transmit levels. In addition, this channel may also carry messages indicating amounts of data to transmit on the reverse link and/or a reverse link transmit stop time.

The Forward Link Hybrid and ACK/NACK Channel

[0016] This channel communicates ACK or NACK bits to one or more mobile stations to support the Hybrid ARQ operation. This channel may be a common channel or mobile specific channel.

[0017] FIG. 1 illustrates a receive power budget for an uplink channel; however, in CDMA type systems this can be thought of as a "total" noise or interference budget. A portion of the budget shown as N_oW is the total background or thermal noise in the bandwidth W. The value Λ is the total amount of received power that the receiver can accept. The value Λ is typically defined such that Λ/N_oW = 3-6dB. I_{OC} refers to the interference received from other base stations or sectors. Values S_l through S_n refer to the amount of power received at the base station from all power controlled channels and voice users 1 through n. S_{data} refers to the remaining received power available to other users such as data users.

[0018] In CDMA type systems, for each user's signal received by the base station all of the other users' signals appear as noise. For example, if there are no data users, the total noise received at the base station with respect to user signal S_2 is the sum of N_oW, I_{OC}, user signal S_1 and user signals S_3 through S_k. CDMA systems use power control for each of the users to limit the received signal power so that it satisfies an acceptable error rate while minimizing the power received by the base station so as to minimize the noise with respect to other user signals.

[0019] S_{data} represents the available receive power or interference that may be received as a result of another user, such as a data user, without causing unacceptable error rates in other user signals received at the base station. Adding a data user will increase the overall noise and will require an increase in the signal power received at the base station from each user S_1 in order to maintain acceptable error rates for each user. This increase may be executed prior to allowing the data user to transmit to avoid any disruption in transmissions received from users S_i. As a result, the portion of the interference or receive power S_{data} available for a data user is slightly decreased by the increased budget provided to each of the users S_i.

[0020] The data user is instructed to transmit data over the uplink at a standard rate that will be received at the base station with the power level of S_{data} or less. It should be noted the rate may be limited by the channel conditions between the base station and data user and the amount of transmit power that the user has available.

[0021] Each data user is scheduled so that only one data user at a time is using the S_{data} receive power budget; however, S_{data} may be divided into portions assigned to different data users so that the different data users may transmit simultaneously.

[0022] Data users are scheduled to transmit based on parameters such as the quality of service or priority purchased by the user, the amount of data to be transmitted, the time since the last transmission and the time criticality of the data to be transmitted. Generally speaking, scheduling should be scheduled so that the users are treated fairly, interference to other cells or sectors is minimized and the utilization of received data budget S_{data} is maximized.

[0023] The resource management protocol works as follows.

1. Mobile stations request for RL traffic channel. This request consists of size of traffic data to be transmitted (quantized in bytes for example), information about mobile capabilities related to its power class, some auxiliary information related to the transmission, and QoS parameters or requirements such as delay or throughput bounds.
2. The BS stores the above information and measures channel conditions. It computes the maximum receivable power on the packet data channel and the corresponding data rate. A method to measure channel conditions and compute the data rate, based on interference issues, is discussed below.
3. The BS computes a schedule based on the information it has received from all users and the information it has processed. The protocol supports the use of a variety of scheduling algorithms. The schedule can be computed at short intervals (e.g. the duration of one power control group) or long intervals (e.g. the duration of multiple frames). The duration between scheduling events depends on the degree of optimization desired; a short duration results in higher optimization but may require higher overheads and processing speeds.
4. The BS may choose to transmit the value of the maximum allowable transmission rate R, or the corresponding receivable power for the high-speed RL packet data channel (denoted by $S_{data}(R)$). This information can be sent over a forward link channel at an appropriate frequency depending upon the choice of fast or slow scheduling. The computation of $S_{data}(R)$ is based on measurements and some prediction to account for changes in voice activity, and other power controlled services and channels. For any given system, there is a one-to-one correspondence between R and $S_{data}(R)$, as we will discuss later. However, the choice of transmitting R or $S_{data}(R)$ may be based on other considerations such as overheads and power consumption.
5. The BS transmits the identity (or identities) of the user(s) and the corresponding transmit power(s). This information can be sent on the forward link along a common channel or dedicated channel(s). Alternatively, the BS just transmits user identities and the MS's determine the appropriate transmit power level required by using pilot measurements. The details of this technique are explained below.
6. Subsequently the scheduled MS(s) transmits data at a rate allowed by the prescribed transmit power.

7. If the amount of data in the MS's buffer is below a certain threshold (which can be specified and made system dependent), then the mobile station may choose to transmit autonomously without going through the request/ scheduling process.

8. Soft handoff (SHO) users are treated more carefully. Since MS's in soft handoff can simultaneously communicate with multiple BS's, more than one base station may schedule the user. Also, not all BS's in the "active set" may schedule the chosen MS. In this case, more than one option exists.

Soft handoff options

[0024] For mobiles in soft handoff, more than one BS can listen to any RL transmission. These BS's a re called the "active set". In systems such as IS-95 and cdma2000 lx, the uplink pilot and power controlled channels/services follow the OR-of-the-downs rule: if even one BS in the active set commands that the MS decrease its power, then the MS obeys it. Conversely, the MS increases its power if and only if all BS's so command. This is done with a view towards minimizing the interference from SHO users. The same principle can be applied to scheduling: if every BS in the active set schedules a given mobile, then and only then will the mobile transmit. Furthermore, it transmits at the minimum of the power levels (and hence the corresponding data rate) assigned by the BS's in the active set. This is a conservative approach, and hence results in cell shrinkage and lower throughput. Other approaches proposed include scheduling a very low rate channel to every SHO user. This leads to an ad hoc utilization of the channel and interference management. We propose two new solutions:

Option 1. For SHO mobiles (more generally every mobile), strict scheduling deadlines could be maintained for the data services so as to guarantee a minimum QoS at the anchor point where data throughput and delay parameters can be measured. An example of an anchor point is the IWF or the base station controller (BSC). With such a rule, the anchor point instructs all BS's in the active set to schedule a certain MS, if it finds that QoS requirements will be violated. This message is sent over the backhaul to every BS in the active set and overrides scheduling decisions made by the BS's. The MS then transmits at the minimum of all the power levels (and hence data rates) indicated by the BS's in the active set. This allows for "fair" treatment of SHO users and does not suffer from the cell shrinkage problem as earlier. The QoS requirement thresholds can themselves be based on radio link protocol (RLP) timers.

Option 2. SHO users receive scheduling information from individual BS as earlier. If a MS is scheduled by some, but not all, of the BSs in the active set, the MS makes a randomized decision to transmit. This allows for SHO users to transmit sometimes but not always, and in particular does NOT rely on any centralizing of control at the BSC. SHO users will typically pick the transmit power corresponding to the lowest value in order to minimize received interference.

The randomization could be biased based on interference considerations, and can be set or changed during operation.

In general, for hybrid ARQ to work for SHO users, an explicit rate indicator should be used in the RL. Hybrid ARQ for SHO users can be done at two levels - at the BS or at the anchor point. Each BS performs an independent hybrid ARQ operation, which exploits time diversity. On the other hand hybrid ARQ (or Chase combining) can be performed at the anchor point (say, the BSC) by combining sub-packets from various BS's - this exploits both time and space diversity.

Interference Management

[0025] The following section provides an example method to estimate channel conditions (near instantaneous or short term channel loss coefficients on the reverse link) in order for the base station to determine the maximum possible rate at which any given mobile can transmit in the reverse link. This is done with a view towards managing inter-cell and intra-cell interference.

[0026] Consider users in a given sector serviced by a BS offering various classes of traffic. Each class of service is treated differently. For example, voice may be served using power controlled channels, and delay tolerant data is best served using rate controlled shared channels. At any given instant every BS maintains a threshold A for the tolerable received power. This threshold is usually set based on the characteristics of the receiver hardware at the BS, as well as coverage considerations. Typically A is specified with reference to the thermal noise power N_oW. Within certain margins of safety, it is important to ensure that the aggregate received power at the BS does not exceed the threshold A. This condition may be required every instant, or on average over a fixed duration. In the latter case, A is a function of time. Since the aggregate power bin consists of signals from various sources which are seen as interference by each other, we also'refer to it as an "interference bin" whose size is A. As long as the aggregate received power at the BS is below the threshold A, the base station can admit new users into the system. This criterion forms the basis for

the following interference management calculations.

[0027] Let there be k voice (and other power controlled) users in the system whose received powers are S_i (for i=1 to k). Let R_i be their transmission rates. Referring to Fig. 1, let S_{data} denote the remaining portion of the interference bin which we wish to allocate to a data user. Let S_{data} (R) and $(E_b/N_t)_R$ denote the power and target SNR-per-bit, respectively, that should be received at the BS to support a rate R in a bandwidth W with a desired packet or frame error rate (say 1%). The relation between S_{data} (R), $(E_b/N_t)_R$ and R is simple:

$$S_{data}(R) = \left(\frac{E_b}{N_t}\right)_R \left(\frac{R}{W}\right)(N_o W + (\Lambda - S_{data}(R))) \qquad (1)$$

[0028] Given a leftover power S_{data}, in order to determine the highest supportable rate, the BS proceeds as follows.

1. For every rate in the pre-specified (discrete) rate set, the BS computes the corresponding $S_{data}(R)$ using equation (1). These can be tabulated.
2. From this table, the BS picks the largest value of R for which the required power S_{data} (R) does not exceed S_{data}.

[0029] This ensures that the desired packet error rate condition is always met.

[0030] N_o and Λ are system dependent parameters, which are typically available only at the BS receiver. If the value of S_{data} is to be used by the mobile to compute R, then N_o and A will also have to be broadcast periodically.

[0031] An important observation is that equation (I) is not particular to any user - it just computes the maximum data rate receivable by the BS given a certain portion of allowable received power S_{data}. Let the i-th mobile's signal experience a channel loss L_i. Then, the required transmit power P^i_{data} (R) to achieve the data rate is

$$P^i_{data}(R) = S_{data}(R).L_i\,. \qquad (2)$$

[0032] Based on the estimates of P^i_{data} (R) (which in turn requires an estimate of the channel loss L_i) and other considerations such as fairness and QoS, interference etc., the scheduling algorithm chooses one or more users at a time and grants them permission to transmit on the uplink. In the above equations, we used "steady state," i.e. time invariant expressions for S_{data} (R) and L_i. In a real system, the received power accrued from each power controlled channel varies in time due to power control and channel variations, which we indicate by the time variable t. As a result, the aggregate received power also varies, and so does $S_{data}(R)$. Further, the channel loss $L_i(t)$ is unknown to both the BS and the MS. In the following, we describe methods of computing S_{data} (R, t), $P^i_{data}(R,t)$, and $L_i(t)$.

A. Computing leftover power S_{data}

[0033] Let $S^{PC}_j(t)$ denote the instantaneous received powers of the j-th power controlled (PC) uplink channel. These include voice traffic channels of users, their uplink pilot codes, and any control and signaling channels. Note that the data rates of these PC channels are known a priori. Therefore, the desired steady state value (under full loading) of the received power that ensures satisfactory error rates on each of these channels can be calculated using Equation (1); denote this steady state value by S^{PC}_j. Also, let $I_{oc}(t)$ denote the interference from the neighboring cells.

[0034] For each PC channel, power control attempts to ensure that $S^{PC}_j(t)$ S^{PC}_j, but usually does not succeed due to load and channel variations. Hence, it is important to estimate these carefully in order to compute a safe value for S_{data} (R,t), i.e., one that ensures that the interference bin threshold A is never exceeded. This can be done in different ways.

1. The received power for all PC channels is exactly what is measured at time t. Then,

$$S_{data}(R,t) = \Lambda - \sum_j S_j^{PC}(t) - I_{oc}(t) \qquad (3)$$

2. The received powers for all PC channels are invariant and taken to be their steady state values. Then,

$$S_{data}(R,t) = \Lambda - \sum_j S_j^{PC} - I_{oc}(t) \quad (4)$$

This can be simplified further by assuming a steady state value I_{oc} for $I_{oc}(t)$, which makes $S_{data}(R, t) = S_{dara}(R)$ time invariant. This assumption is valid over long durations and hence the above rule is useful for "slow" scheduling.

3. The received power for all PC channels is always estimated to be the maximum possible. Then,

$$S_{data}(R,t) = \Lambda - \sum_j \max(S_j^{PC}(t), S_j^{PC}) - I_{oc-\max} \quad (5)$$

where $I_{oc\text{-}\max}$ is a prespecified maximum value of expected other cell interference. This is very conservative and results in allocation of minimum remaining power for data users. This leads to under-utilization of the interference bin, but is always safe.

4. The penalty imposed on the data power in the option 3 above can be alleviated somewhat by using the maximum value for aggregate received power from all the PC channels.

$$S_{data}(R,t) = \Lambda - \max(\sum_j S_j^{PC}(t), \sum_j S_j^{PC}) - I_{oc-\max} \quad (6)$$

There is some benefit due to the fact that the aggregate power undergoes averaging and hence does not change fast. This can make the estimation of $S_{data}(R, t)$ somewhat simpler and also less susceptible to errors.

B. Estimating the data channel transmit power $P_{data}^{i}(R,t)$ via channel loss coefficient $L_i(t)$.

[0035] We previously stated (see Equation(2)) that the BS schedules users based on knowledge of the required MS transmit powers $P_{data}^{i}(R)$. Estimation of the (time varying) transmit power $P_{data}^{i}(R, t)$ requires an estimate of the channel loss coefficient $L_i(t)$. The desired accuracy of the estimate depends on the scenario of interest. We now outline three methods that are novel and explain their applicability in different scenarios.

1. The i-th MS determines its own channel loss coefficient $L_i(t)$, by averaging the path loss coefficients observed in the forward link via the BS pilot measurements. This averages out short term channel variations and mostly reflects just the path loss and shadow fading effects; hence the estimate of $L_i(t)$ is approximately equal to L_i. In other words, the MS gains knowledge of the channel losses due to its geographical position, but cannot track Rayleigh fading. Subsequently the MS reports the calculated value of $L_i(t)$ periodically to the BS. This method is especially suited for slow scheduling.

2. Every MS begins with a fixed reference pilot at "fixed" power, and subsequent pilot transmissions may be power controlled by the BS. The BS keeps track of the PC loop and estimates the transmit power in the instantaneous pilot. The BS also measures the received power in the instantaneous pilot signal and estimates the instantaneous channel loss coefficient $L_i(t)$. Note that the power control commands may be received in error at the BS and hence the pilot transmit power tracking may deviate from the true value. This is especially true in SHO situations. In order to rectify this, the MS sends the reference pilot at the predetermined "fixed" power periodically. This allows for the BS to resynchronize with respect to the pilot power and thereby correct its estimate of $L_i(t)$. Local corrections in the tracking algorithm can be made if the received power at a given instant is above that corresponding to the expected transmit power. However, these local corrections have limited applicability since the higher than expected received power may be due to instantaneous changes in channel conditions and not just due to the variable user load. Further, if the fixed power reference pilot transmissions from all MSs are synchronous, the interference pattern at the BS displays some periodicity and impulsive nature, which is undesirable. In order to limit the combined interference from all users transmitting pilot of fixed power, we stagger the instants at which each user transmits the periodic reference pilot.

3. In some situations, it may be undesirable to transmit the pilot at a fixed power since this may create high interference to other users. The following can be adopted as an alternative to sending the pilot at a fixed power. The MS sends an explicit signaling message informing the BS periodically of the transmit power in the pilot signal. The

BS can now resynchronize in case of error in PC loops. This method of estimating instantaneous value of $L_i(t)$ is especially suited for fast scheduling.

4. In yet another alternative method, the mobiles estimate the value of $L_i(t)$ based on the ratio of the RL transmitted pilot power and an estimate of the received pilot power at the BS. The method works as follows: Let $S^i_{pilot}(R_{pilot}, t)$ and R_{pilot} be the received pilot power and effective pilot channel data rate of the i-th user at the BS (note that R_{pilot} is the same for all MS's). As before, $S_{data}(R, t)$ and R denote the received traffic channel power and data rate at the BS. Since both the pilot and traffic channel signals transmitted by the i-th MS are subject to identical channel conditions, the following relationships hold.

$$P^i_{pilot}(R_{pilot}, t) = S^i_{pilot}(R, t).L_i(t) \tag{7}$$

$$P^i_{data}(R, t) = S_{data}(R, t).L_i(t) \tag{8}$$

Substituting for $L_i(t)$ from Equation (7) into Equation (8), we have

$$P^i_{data}(R,t) \text{ and } P^i_{pilot}(R_{pilot}, t)\frac{S_{data}(R, t)}{S^i_{pilot}(R_{pilot}, t)}, \tag{9}$$

Now, we only need the second term on the right hand side above, which is the ratio of the data and pilot channel received powers at the BS. Rewriting Equation (1) for $S_{data}(R, t)$ and $S^i_{pilot,t}(R_{pilot}, t)$, we have

$$S_{data}(R,t) = (N_o W + \Lambda)\left[\frac{\left(\frac{E_b}{N_t}\right)_R R}{W + \left(\frac{E_b}{N_t}\right)_R R}\right] \tag{10}$$

$$S^i_{pilot}(R,t) = (N_o W + \Lambda)\left[\frac{\left(\frac{E_b}{N_t}\right)_{pilot} R_{pilot}}{W + \left(\frac{E_b}{N_t}\right)_{pilot} R_{pilot}}\right] \tag{11}$$

Subsituting for $S_{data}(R, t)$ and $S^i_{pilot}(R_{pilot}, t)$ from Equations. (10) and (11) into Equation (9), we obtain

$$P^i_{data}(R,t) = P^i_{pilot}(R_{pilot}, t)\left[\frac{\left(\frac{E_b}{N_t}\right)_R R}{\left(\frac{E_b}{N_t}\right)_{pilot} R_{pilot}}\right]\left[\frac{W + \left(\frac{E_b}{N_t}\right)_{pilot} R_{pilot}}{W + \left(\frac{E_b}{N_t}\right)_R R}\right] \tag{12}$$

[0036] Note that R (or $S_{data}(R,t)$, N_o, and Λ is known to all MS's since the BS broadcasts this information. Further, the i-th MS knows the exact pilot power $_{data}(R, t)$ and $S^i_{pilot}(R_{pilot}, t)$, and also the other quantities required to evaluate Equation (12). Thus, the mobile obtains an estimate of the data channel transmit power $_{data}(R, t)$ and $S^i_{data}(R, t)$ via an implicit estimate of the channel loss $L_i(t)$, using the well-known pilot channel as a reference. Any power-controlled

channel with a well-known data rate may be used as a reference instead of the pilot.

[0037] Some of the auxiliary issues related to the above calculations (independent of the method) include:

1. The BS has to provide some margins for I_{oc} (t), and variations due to PC loops, fading etc.
2. For mobiles in soft handoff, some but not all of the BSs in the active set may schedule a MS. If the MS chooses to transmit, it picks the lowest rate among the choice of rates broadcast by the various BSs. This may lead to interference in those BS's which did not schedule the MS. But this can be managed by building margins in $I_{oc}(t)$ as discussed above.
3. All data mobiles in a given cell should be synchronized at the slot level with the PCG and across sectors/cells.
4. Scheduling one or more users at a time depends on a balance of frame fill efficiency and the necessary downlink signaling overheads.
5. Fast scheduling works best with one user at a time (to manage overheads). This not only eases the problem of interference management, but also makes the design of scheduling algorithms easier. Numerous results exist on the optimality of scheduling one user at a time. Further, every additional user further increases interference to voice users since the user-specific spreading codes used on the uplink are not orthogonal. On the other hand, the efficacy of fast scheduling also depends on the control overheads needed to enable it.
6. Sometimes it may happen that the scheduled user's received signal is not strong enough to fill the interference bin even when transmitting at maximum allowed power. In such situations, it may still be useful to schedule additional users so that the available interference bin is fully utilized. Consequently, the available received power S_{data} (R,t) is appropriately split, and the value R^1 (or $S_{data}^{\,i}$ (R^i,t)) is communicated to the i-th MS.
7. Data traffic originating at a mobile may be such that small packets need to be sent on the uplink quite often. This happens when TCP acknowledgments (ACKs) (which are typically 40 bytes long) need to be sent for data packets received on the downlink. For downlink intensive services such as web browsing, ACKs form a large fraction of uplink traffic. Hence it may be desirable to send them on a dedicated power controlled uplink code channel. Such a channel may be of sufficiently low rate, and gated off when not necessary. This is beneficial since returning the ACKs without any scheduling delay has a salutory effect on TCP and keeps the downlink pipe well utilized. The ACK packets can also be time multiplexed with other control information on existing uplink control channels such as the Reverse Fundamental Channel of cdma2000 lx. Finally, such dedicated channels can always be accounted a priori in the calculation of S_{data} (R).

Claims

1. A method for receiving information used for controlling uplink communications, comprising the steps of:

receiving reverse pilot channel transmit power information on a first channel; and
receiving traffic data size information on a second channel.

2. The method of claim 1, wherein the channels are distinguished using time.

3. The method of claim 1, wherein the channels are distinguished using Walsh codes.

4. The method of claim 1, further comprising the step of receiving data rate information on a third channel.

5. A method for controlling uplink communications, comprising the steps of:

receiving a reverse link traffic channel request having traffic data size information and a user station's capability information;
using the traffic data size information and the user station's capability information to schedule the user station's use of a reverse link; and
transmitting information to the user station indicating a reverse link start transmit time.

6. The method of claim 5, further comprising the step of transmitting information specifying a transmit level to be used by the user station on the reverse link.

7. The method of claim 5, further comprising the step of transmitting information specifying a transmission rate to be used by the user station on the reverse link.

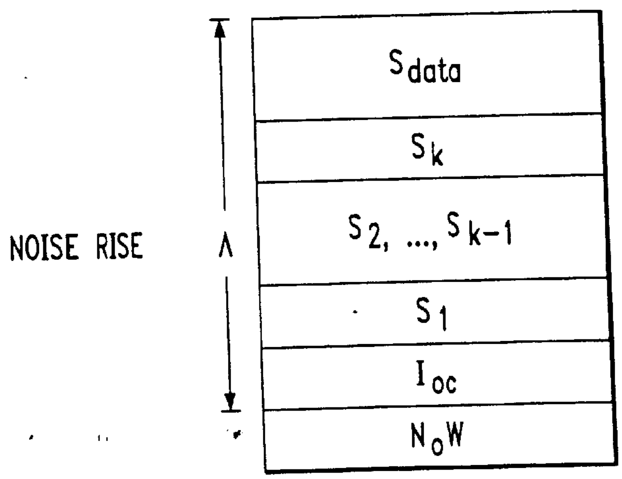
8. The method of claim 7, further comprising the step of transmitting information specifying a transmit level to be used by the user station on the reverse link.

9. A method to control uplink transmissions in a wireless communication system, comprising the steps of:

transmitting an increase transmit power command to a plurality of voice users in anticipation of transmission by at least one other user;
communicating an uplink data rate to the at least one other user; and
receiving data from the at least one other user over an uplink channel at the uplink data rate.

10. The method of claim 1, further comprising the step of communicating an uplink transmission duration to the at least one other user.

FIG. 1



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EUROPEAN SEARCH REPORT

Application Number
EP 01 30 9732

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H04Q
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 March 2002	Amorotti, M

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